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GIBBON'S DUPLEX STREET RAILWAY TRACK.

[*Report of the Committee on Science and the Arts.*]

[No. 1,643.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 1, 1892.

The Sub-Committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred for examination,

GIBBON'S DUPLEX STREET RAILWAY TRACK,

report, That the system embraces a form of construction for street railways that dispenses with wooden sills and cross-ties, and substitutes therefor metal chairs and tie-bars as supports and braces, for a system of double rails of peculiar construction, in which the head and flange rails are separate, each having a wide depending web directly under the load-bearing surface. These two sections, when united, form a complete rail, making a very stiff longitudinal stringer, laid

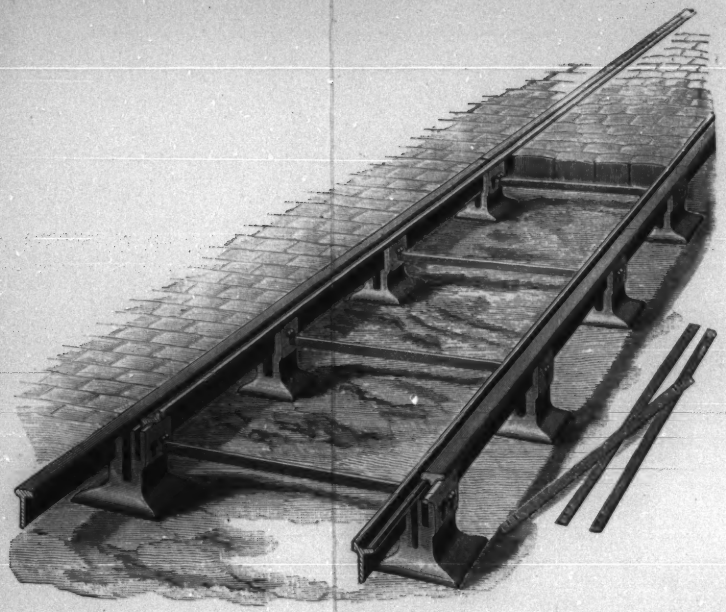

FIG. 1.

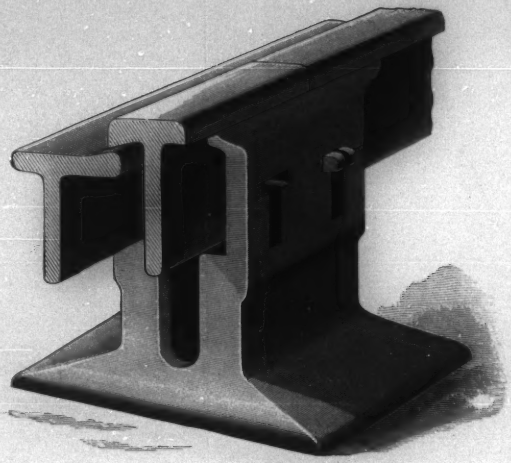

FIG. 2.

FIG. 1.—Gibbon duplex rail construction.
" 2.—Joint chair and rail.
" 3.—Duplex rail.
" 4.—Cross-section at chair.
" 5.—Longitudinal section at joint.
" 6.—Tie-bar.
" 7.—Wedge-key.

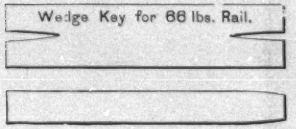

FIG. 7.

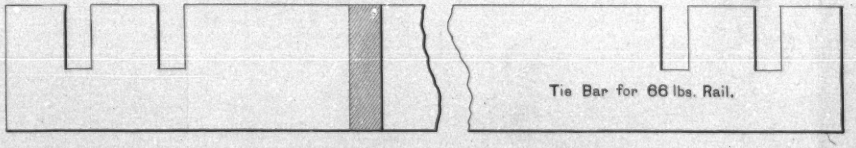

FIG. 6.

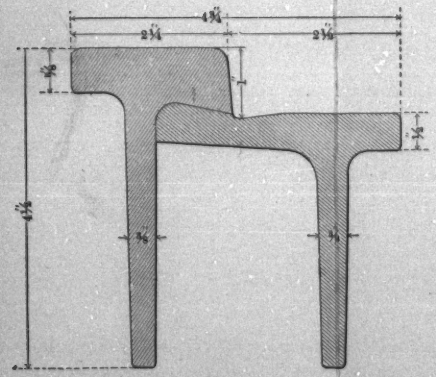

FIG. 3.

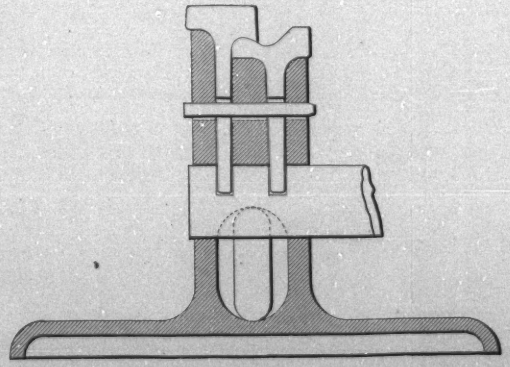

FIG. 4.

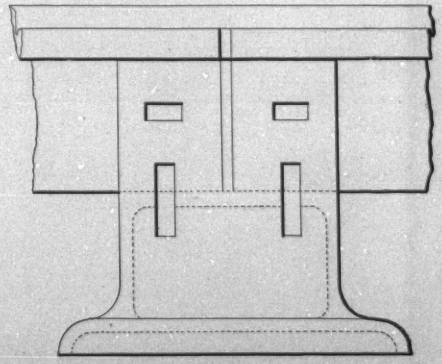

FIG. 5.

THE GIBBON DUPLEX STREET RAILWAY TRACK.

THE GIBBON DUPLEX STREET RAILWAY TRACK IN COURSE OF CONSTRUCTION.

THE GIBBON DUPLEX STREET RAILWAY TRACK.—FINISHED TRACK.

to break joints, so that when the head sections meet they are supported by the solid portion of the flange section, and where the latter join they are covered partially by the solid head section, thus practically forming a jointless track of uniform strength and elasticity throughout its entire length.

A transverse section of this track exhibits two double rails—two cast-iron chairs, one tie-bar and two lock-wedges, as shown in the accompanying illustrations.

It will be noted that no spikes or threaded bolts are used, that the gauge of the track is absolutely uniform and permanent, being controlled by the notched tie-bars which receive the webs of the rails. Two patterns of cast-iron chairs are preferably used; the joint chair having slots and key-ways to receive two tie-bars and two key-wedges, and an intermediate chair having but a single tie-bar, slot and key-way.

The tie-bars are made from flat steel about two inches by one-half inch at each end to any desired gauge, to receive the webs of the rails.

The keys or wedges are split at one or both ends, and, being driven through the key-ways of the chairs directly over the tie-bars, and through openings in the webs of the rails, are securely held in place by slightly spreading the split ends, so that they will not come out accidentally, but are not difficult to remove when necessary.

The claims of superiority advanced for this system are fully discussed and illustrated in the letters patent Nos. 429,127 and 429,128, dated June 2, 1890, and other papers forming an appendix for reference; but briefly stated, they appear under the following heads:

(1) "Durability and permanence, inherent to an all-metal system." This claim passes without question.

(2) "Smoothness and stability of the track, which is absolutely free from weak points."

When a track is constructed so that the ends of the rails cannot yield to the passing load, the worst of all track-destroying causes is removed, and such a road must retain its smoothness and stability until the rails are entirely worn out throughout their length.

(3) "Increased vertical and lateral strength without increase of metal."

The double rail with the two vertical webs combined and secured by the metal chairs, tie-bars and wedges, is naturally very stiff, in all directions; this is mainly due to the better disposition of the metal with relation to the direction of the load and strain.

(4) "Freedom from torsional strain, the bearing surfaces being directly supported by the vertical webs."

The prevailing form of a street track in America provides for two kinds of service, a head to carry the car and a flange upon which other vehicles may run.

In single girder rails, the one vertical web is not placed directly under either of these load-bearing portions, but between them, so that there is no direct support for either car or wagon, which brings upon such a track a serious and injurious twisting strain. In the Gibbon rail, which has the two vertical webs directly under each of the load-bearing surfaces, similar twisting is impossible.

(5) "Increased wearing capacity of head rail."

On tracks constructed so that wagons cannot travel upon them, or where the wagon travel is much lighter than the car service, the head of the rail will wear out most rapidly; when this occurs upon a single girder rail the entire rail must be discarded as scrap, while with the Gibbon system, only the head rail need be renewed, and the discarded part is but half the weight of the single girder.

(6) "In renewal, the discarding of the worn portion only is necessary."

The advantage of retaining either half of the rail in service until it is worn out, adds greatly to the life and economy of such a track.

(7) "Perfect alignment and accurate maintenance of gauge with requisite freedom for expansion and contraction."

The union of the rails with the tie-bars and keys at the chairs is such that, while the rails are firmly seated in the chairs and securely held down by the keys, the eyes in the rail-webs being longer than the width of the keys, ample play for expansion is provided.

(8 "Simplicity of construction which expedites the track laying and reduces the disturbances of the public streets."

Every piece of the Gibbon track is of the simplest form and inexpensive to make, and in the construction of a mile of track but 7,850 pieces are required, while some of the permanent single girder tracks are made up of over 26,000 pieces and the common tram rail uses 17,406 pieces per mile. In excavating for these tracks the quantity of earth to be removed bears about the same ratio, viz: for the Gibbon track 300 cubic yards and for the others 1,064 cubic yards, and 932 cubic yards, respectively. These advantages bring the cost of the superior all-metal Gibbon track within the cost of the ordinary tram track.

(9) "Maintenance of absolute contact of metal, which obviates the necessity of 'bonding joints' for electrical traction."

This claim is doubtless well founded; the method of connecting the rails at their ends is such that for electrical service the track is found to be practically and permanently as one continuous rail.

(10) "A reasonable first cost, and great saving in maintenance."

For reasons above stated, this claim must be conceded.

From a careful examination of this system and an inspection of tracks in practical use, it is evident that much that has long been desired in the direction of a better and more lasting construction, permanent smoothness and strength equal to the heavy traffic that they are subject to, has been carefully and ably worked out upon a thoroughly practical and economical line, in every detail.

The special requirements of electrical traction and cable service appear to be fully met, so that we have an excellent substitute for every objectionable form of track now commonly used.

An invention that will contribute so much to the daily comfort of every one who must use the street cars, and that at the same time materially reduces the annoyance of the ever-recurring repairs to the present prevailing systems, commends itself to the highest appreciation of all.

We therefore respectfully recommend the grant to the inventor of the award of the John Scott Legacy Premium and Medal.

H. R. HEYL, *Chairman*; J. M. EMANUEL,
SPENCER FULLERTON, CHAS. E. RONALDSON,
ARTHUR BEARDSLEY, G. MORGAN ELDRIDGE,
L. L. CHENEY.

Adopted, May 4, 1892.

ARTHUR BEARDSLEY,
Chairman of the Committee on Science and the Arts.

THE DEVELOPMENT OF AMERICAN ARMOR-PLATE.

BY F. LYNWOOD GARRISON.

[*Continued from p. 356.*]

Alloyed Steel Armor.—As far as the author can determine the use of what has been termed "alloyed steels" for the manufacture of armor-plate was begun on an entirely experimental basis, about the year 1881.

During this year, some *chrome* steel plates made at Creusot and at Unieux were tested at the Gavre proving grounds in France. These plates were composed of square slabs, fastened to a solid backing of iron.

The experiments were not so successful as anticipated, the first projectile shattering the plate almost to pieces. This result was attributed to the fact of the iron backing not being sufficiently solid, and to the difficulty of getting the iron and steel to make an efficient compound.*

Since 1881, some few experimental plates of chrome, manganese or copper steels have been made in France; as far as the author knows the results were not made public, and he infers they could not have been satisfactory.

The one alloyed steel, which has been used to any extent

* *Journal of the Iron and Steel Inst.*, No. 1, 1881, p. 329.

within the last two or three years, is nickel steel; it was first used in a practical manner as armor-plate in France.

Henri Schneider, of Creusot, in his patent specifications for the manufacture of alloys of steel and nickel, and steel and copper, mentions that such alloys are especially adapted or suitable for use in the construction of armor-plates.* For several years it has been a well-known fact amongst metallurgists that alloys of certain properties of nickel and steel are made more thoroughly homogeneous, stronger and harder by the presence of the nickel. Nickel steel withstands punching without cracking to a marked degree; it forges, rolls and tempers well, and can be cast into shapes without difficulty.

In 1891, Capt. Tresidder obtained a British patent† for the use of a nickel steel back instead of wrought iron or steel, in the manufacture of the Ellis (Brown & Co.) compound plates.

He states in the specification that about two per cent. of nickel is added to the Siemens-Martin steel used for the purpose, also that such nickel-steel is equally applicable to compound plates made in any other manner. The use of these nickel-steel backs is possibly as important if not the most important factor in the success of the so-called Tresidder process which will be considered later on.

One of the first nickel-steel plates made by Schneider & Co., at Creusot, was tested by the Russian Government at Ochta, November 11, 1890.

The now famous nickel-steel plate, tested at Annapolis in September, 1890, was made at Creusot about a year after the Ochta plate, and, as a consequence, might be expected to be the superior owing to the improvements which naturally would be made in the process of manufacture during that interval.

The Ochta plate did not develop as good qualities as had been expected, but it proved much superior to the Brown compound plate, and the Vicker's all-steel plate

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*U. S. Patents 415,655 and 415,654, November 19, 1889.

† No. 2,552, of 1891.

tested at that time; only two of the projectiles getting their points beyond its back.

The rebounding of the projectiles from the nickel-steel plate showed it to be much more elastic than the all-steel, the latter acting more like good wrought iron when attacked by projectiles of the best quality. One especially noticeable feature in the nickel-steel plate should be kept in mind—that of the little effect of its many cracks on the penetration of succeeding projectiles.*

M. Barba states† that he cannot see the necessity of seeking so earnestly the suppression of cracks since they do not exercise any influence upon perforation. By giving the steel a laminated structure, assisted by the introduction of nickel, it is possible to keep back the apparition of cracks, but M. Barba did not think in any metal they could be done away with altogether.

It is difficult to determine just how the nickel acts in a beneficial manner when added to steel; that nickel has a very strong affinity for iron, we have demonstrated in its almost invariable presence in meteoric iron.

Vickers denies the supposition that nickel could give a laminated structure to cast steel. He states that when a projectile strikes a plate the metal must be distorted, and if that leads to cracking, it is likely to be called lamination. He had noticed cracks beneath and parallel with the surface were often thought to be due to lamination.‡

Barba states that the presence of cracks depend very much upon the nearness of the point of impact of the shot to the edge and that they might be prevented by the proper metallurgical treatment.§

Mr. W. H. White (Director of Naval Construction of the British Admiralty) states, that he has seen cracks take place

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* *The Year's Naval Progress*, p. 303. Washington, 1891.

† *Proceedings of the Institution of Naval Architects*, 1891. *Engineering*, vol. li, 1891, p. 393.

‡ *Ibid.* (*Engineering*), p. 393.

§ *Ibid.*, p. 396.

FIG. 6.—Creusot nickel-steel plate.

FIG. 7.—Creusot nickel-steel plate (back)

at some distance from the shot. What the cause might be it is difficult to say, and how far the effect might be serious for cracks of given dimensions, it was also difficult to decide.*

The results of the Annapolis trials of 1890 are too well known to need further comment.† The resistance obtained with the nickel-steel plate far exceeded the expectations. At the fifth shot, with a striking energy of 4,988 foot-tons, an eight-inch armor-piercing projectile broke in many pieces after having forced its point but ten and one-half inches beyond the back and without developing a sign of a crack. (See *Plate I.*) This armor-plate showed as much homogeneity as the steel one, but was tougher and more tenacious. (*Figs. 6* and 7.) Never before, in the history of modern armor, had a plate given results to compare with these; withstanding a total energy of 16,940 foot-tons—1,835 foot-tons per ton of plate—without developing a single crack and without being perforated.‡ The dimensions of both these nickel-steel plates were much the same, the Ochta being 8 x 8 feet square and about ten inches thick, and the Annapolis 6 x 8 feet by 10½ inches thick.

They differed somewhat in composition, containing unequal proportions of nickel. Up to the time of the Annapolis trials no nickel-steel plates of any great size appear to have been made in England, although about that time and since, considerable quantities of four-inch nickel-steel deck plates have been made and tested on board the *Nettle*, with very satisfactory results.§ It has been officially stated such plates yielded results seventy-five per cent. above similar plates ever tested in England.‖ Similar results were obtained by the French, Danish and Chilian Admiralty officials.

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* *Engineering*, p. 396.

† See *The Year's Naval Progress*, July, 1891. *Proceedings of the U. S. Naval Inst.*, vol. xxi, No. 5. *Journ. of the Franklin Inst.* Report of the Secretary of Navy.

‡ *Ibid.*, p. 326.

§ *Journal of the Iron and Steel Inst.*, No. 11, 1891, p. 51.

‖ *Trans. of the Am. Inst. of Mining Engineers*, vol. xix, p. 832.

At the present time the development of nickel-steel in England appears to be in its application to compound plates by the system of Captain Tresidder already mentioned.

The author assumes the nickel-steel deck plate made in this country to have given equally good results. Some of it made by Carnegie, Phipps & Co., showed by analysis the following composition:*

	I.	II.
Carbon,	0·90	0·88
Phosphorus,	0·018	0·021
Manganese,	1·05	1·101
Silicon,	0·059	0.078
Nickel,	2·39	2·50
Sulphur,	0·014	0·016
Specific gravity,	7·801	7·853

This metal is presumably up to the United States Navy standard of 85,000 pounds tensile strength and twenty per cent. elongation.

Two nickel-steel plates of 10·43 and 9·84 inches in thickness, respectively, were tested at Gavre, in July, 1891, yielding results very similar to those obtained with the Creusot nickel-steel plate at the Annapolis trials of 1890.†

Triple Alloys.—What might be termed triple alloys of steel are beginning to attract some attention, and it would seem probable in the near future they may be used to some extent in the manufacture of armor-plate. Already the *Compagnie des Hauts-Fourneaux, Forges et Aciéries de la Marine et des Chemins de Fer* in France have made some experimental armor-plate of a 0·4 per cent. carbon steel with one per cent. chromium and two per cent. nickel, the steel being first melted in an open-hearth furnace in the ordinary way. When the silicon and manganese normally present in the steel have attained their proper proportions, the nickel and chromium are added successively in the form of ferro-nickel and ferro-chrome, or in the shape of a double ferro-chrome and nickel.‡

* The author is indebted for this analysis to Mr. James S. de Benneville, of Philadelphia.

† *Le Yacht*, October 24, 1891.

‡ *Engineering and Mining Journal*, January 23, 1892, p. 131.

The design of the alloy is obvious, as it is evident the nickel is intended to give the toughness and the chromium the hardness.

If by this means conditions in armor-plate could be obtained similar to those in the Harvey treated nickel-steel plates at the recent Indian Head trials, we would truly have an ideal plate—ideal at least until the power of the gun has outgrown its present proportions. The author ventures to hope this ideal will at least in some measure be realized, for he believes the development of armor-plate in this direction to be the true one.

The recent armor-plate trials held at Indian Head, Md., the subject of which should properly constitute this paper, were held in three series, the first October 31st, the second November 14, 1891, and the third January 13, 1892.

Commander Wm. M. Folger, Chief of the Bureau of Ordnance, Navy Department, having requested that the Franklin Institute be represented at these trials, the author had the honor of being selected as its delegate.

He was present at the first two series, but owing to the date of the third having been decided upon somewhat unexpectedly, he was unable to attend. The results of the third series were, however, of comparatively little interest, being more or less of a repetition of those of the first and second series.

It was the intention of the Navy Department to test three plates of different composition at each of the three series, making a total of nine plates, all substantially of the same dimensions and weight.

This plan, however, was only carried out in the first and second series, as but two plates of somewhat irregular dimensions were tested at the third series.

For this reason the author will confine his remarks about these tests chiefly to the first two series, and for the sake of greater accuracy draw more of the details from the official report than from his own notes.*

* The photographs which are used to illustrate these trials are those taken by the Board; the author is indebted to Commander Folger for the loan of the same, and also to the United States Naval Institute, and to the publishers of the *Iron Age* for a number of the others.

The size of each plate was 8 x 6 feet x 10·5 inches and it was fastened to the backing by twelve bolts 2·36 inches in diameter, giving a total bolt cross-section of 52·29 square inches. Further details are—*

Character of Plate.	Maker.	Weight.	Total Bolt Cross-section per Ton of Plate.
		pounds.	*sq. inches.*
High-carbon nickel-steel,	Bethlehem Iron Company,	20,494	5·71
Low-carbon nickel-steel,	Carnegie, Phipps & Co.,	20,844	5·62
Low-carbon steel, Harvey,	Bethlehem Iron Company,	20,506	5·71
High-carbon nickel-steel,	Carnegie, Phipps & Co.,	20,590	5·69
Low-carbon nickel-steel, Harvey,	Carnegie, Phipps & Co.,	20,220	5·79
High-carbon nickel-steel, Harvey,	Bethlehem Iron Company,	20,682	5·66

The targets were set up so that the faces of the plate were on the chords of a circle whose centre was the gun's pivot and whose radius was 73 feet 5 inches. The muzzle of the six-inch B. L. R. was consequently 57·5 feet and the eight-inch B. L. R. 55·5 feet from the face of the plate when the gun was pointed at its centre, the axis of the gun being then perpendicular to the plane of the plate.

The backing was constructed in accordance with the drawings furnished by the Bureau of Ordnance, except that, on account of the length of the armor bolts, on the first day wooden and on the second iron washers were used under the cup washers of these bolts. During the first day's firing some of the wooden washers were split and somewhat compressed and the armor-plate bolt nuts were in some cases tightened between the shots.

The surfaces of the plates were as they came from the makers and were free from paint.

The gun was mounted on a solid platform and protected overhead by a shed of heavy timbers, and in front by a bank of earth, with sand-bags around the chase.

The guns were pointed by means of cross-hair sights in the bore, and were fired by friction primers with a long lanyard leading to the bomb-proof near the gun, 18 feet distant.

In this report "front," when applied to the plate or to fragments thrown therefrom, will mean the direction from the plate towards the gun. The swellings of the plate caused by the projectile will be called the "front bulge" and the "back bulge." "Right" and "left" will be taken as the right or left-hand of a person facing the front of the plate. "Perforation" will indicate that the hole through the plate is in its entire length, as great or greater than the maximum diameter of the projectile.

BALLISTIC DETAILS.

Six-inch B. L. R.

Gun.—Six-inch-B. L. R. of forty calibre: Mark III. No. 120.

Charge.—42·4 pounds Du Pont's brown prismatic powder.

* The details in small type are from the official report of the Board, those in large type, from the author's notes. F. L. G.

Projectile.—Six-inch armor-piercing shell, manufactured by Jacob Holtzer & Co., Unieux, France, brought up to the standard weight of 100 pounds by filling with sand and small fragments of iron.

Striking velocity, determined by previous firings, foot-seconds,	2,075
Striking energy, foot-tons,	2,989
Striking energy per ton of plate, about (foot-tons),	325
Elevation for upper corners,	+ 1° 44′
Elevation of lower corners,	− 1° 24′

Carriage.—Central pivot, Mark IV. No. 93.

Eight-inch B. L. R.

Gun.—Eight-inch B. L. R. of thirty-five calibres, Mark III. No. 18.

Charge.—74·5 pounds Du Pont's brown prismatic powder.

Projectile.—Eight-inch Firminy armor-piercing shell, manufactured by T. Firth & Sons, Sheffield, England, brought up to the standard weight of 210 pounds by filling with sand and small fragments of iron.

Striking velocity, determined by previous firings, foot-seconds,	1,850
Striking energy, foot-tons,	4,989
Striking energy per ton of plate, about (foot-tons),	543

When the Carpenter projectile was used:

Charge.—72·5 pounds of Du Pont's brown prismatic powder.

Projectile.—Eight-inch armor-piercing shell, manufactured by the Carpenter Steel Company, Reading, Pa., brought up to the standard weight of 250 pounds by filling with sand and small fragments of iron.

Striking velocity, foot-seconds,	1,700
Striking energy, foot-tons,	5,008
Striking energy, per ton of plate, about (foot-tons),	345

Carriage.—Central pivot, Mark IV. No. 15.

The total striking energy of the five projectiles was 16,940 foot-tons, equal to about 1,845 foot-tons per ton of plate.

FIRST DAY, OCTOBER 31, 1891.

Weather clear; thermometer at 9 A. M., 52° F.; at 2 P. M., 70° F.

Round 1.

First shot at Bethlehem Iron Company's high-carbon nickel-steel plate. Time, 8:48:45 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the left side of the plate.

The projectile entered the plate and rebounded to the front 31 feet 10 inches, and ricocheted 19 feet 2 inches beyond. The projectile was unbroken, and was shortened 0·06; expanded at bourrelet 0·01, at body 0·03, at base 0·00.

The penetration of the point was 13·25 inches.

A bulge was formed on the face of the plate 16·5 inches in diameter, with a regular and curling fringe of metal about the hole 1·75 inches high, and radial hair cracks in the bulge 4·5 inches and 2·5 inches long.

The bulge on the back of the plate was 16·5 inches in diameter, about the hole 1·75 inches wide; opposite the point of the projectile, from which a star of cracks opened out. A piece of metal about one-third the bulge was scaled off the back of the plate.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 1·75 inches deep.

The head of one of the side plate bolts was broken.

(See *Figs. 8, 9* and *14.*)

A through crack was subsequently developed at this point. The penetration was somewhat less than the first shot at the Creusot nickel-steel plate of the Annapolis trials in 1890.

Round 2.

First shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel plate. Time, 8:56 A. M.

Gun—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the left side of the plate.

The projectile entered and remained in the plate apparently intact, with its base 9·75 inches inside the face of the plate.

The estimated penetration of the point was 26·53 inches.

A bulge was formed on the face of the plate 18·5 inches in diameter, with a regular and curling fringe of metal about the hole 1·75 inches high.

No cracks.

When the plate was removed from the backing the projectile remained in the latter, with its base 1·5 inches from the normal surface thereof.

The bulge on the back of the plate was 16·5 inches in diameter, and 4·87 inches high about the hole through which the projectile passed.

The indent in the backing corresponded in shape to the bulge, and was 11 inches in diameter and 4 inches deep. Two small pieces of the plate adhered to the backing. One of the side plate bolts was loosened.

(See *Figs. 10, 11* and *14.*)

A thorough crack was subsequently developed at this point.

Round 3.

First shot at Bethlehem Iron Company's low-carbon steel Harvey plate. Time, 9:9:50 A. M.

Gun—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the left side of the plate.

The projectile entered and broke up; the head split into twelve pieces with a very jagged fracture and remained in the plate, and the base was broken into small pieces, one of the larger of which being found 100 yards

FIG. 8.—High-carbon nickel steel, Bethlehem.

FIG. 10.—Low-carbon nickel steel, Carnegie (face)

FIG. 12.—Harvey low-carbon steel, Bethlehem (face).

FIG. 9.—High-carbon nickel steel, Bethlehem (back).

FIG. 11.—Low-carbon nickel steel, Carnegie (back).

FIG. 13.—Harvey low-carbon steel, Bethlehem (back).

THE INDIAN HEAD ARMOR TESTS.—TEN AND ONE-HALF INCH NICKEL STEEL

PART THEREOF TREATED BY THE HARVEY PROCESS. FOUR RO

Fig. 15.—High-carbon nickel steel, Carnegie.

FIG. 17.—Harvey low-carbon nickel steel, Carnegie (face).

FIG. 19.—Harvey high-carbon nickel steel, Bethlehem.

FIG. 16.—High-carbon nickel steel, Carnegie.

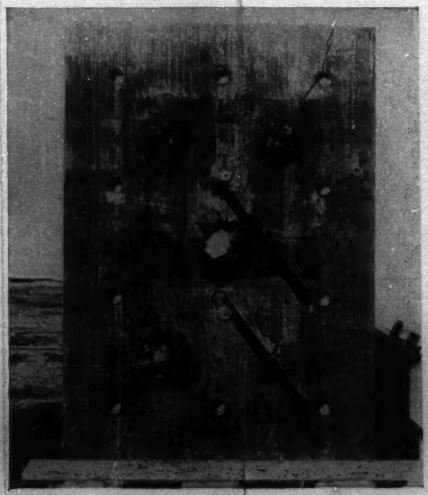


FIG. 18.—Harvey low-carbon nickel steel, Carnegie (back).

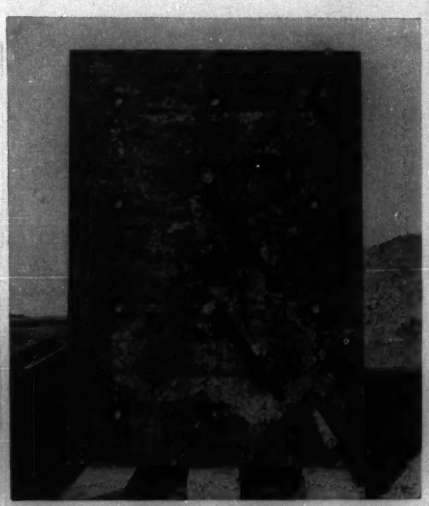


FIG. 20.—Harvey high-carbon nickel steel, Bethlehem.

STEEL PLATES BY CARNEGIE, PHIPPS & CO. AND BETHLEHEM IRON COMPANY.

OUR ROUNDS SIX-INCH B. L. R., ONE ROUND EIGHT-INCH B. L. R.

to the front. The front end of the charge chamber was 2·75 inches inside the face of the plate.

The estimated penetration of the point was 10·07 inches.

A bulge was formed on the face of the plate, 19 inches in diameter, with a maximum height about the hole of 0·75 inch. There was no curling fringe, but the metal about the hole chipped off.

The bulge on the back of the plate was 16 inches in diameter and 2 inches high, with a star of cracks opening from the point of the projectile.

The backing showed a slight depression, corresponding in shape to the bulge, 12 inches in diameter and 1·5 inches deep.

Two of the side plate bolts were loosened.

(See *Figs 12, 13* and *14.*)

Round 4.

Second shot at Bethlehem Iron Company's high-carbon nickel-steel plate. Time, 9:20:28 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 22·5 inches from the top and 24 inches from the right side of the plate.

The projectile entered and broke into several pieces, the head with a jagged fracture and split into three equal pieces remaining in the plate. The front end of the chamber was 2·75 inches inside the face of the plate.

The estimated penetration of the point was 10·07 inches.

A bulge was formed on the face of the plate 18·5 inches in diameter with a regular and curling fringe about the hole 1·75 inches high. Three short surface radial cracks were developed in the bulge, 2 inches, 2·5 inches and 2·75 inches long.

The bulge on the back of the plate was 17 inches in diameter, and 2·12 inches high; about the hole one inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 1·37 inches deep.

One of the side plate bolts was loosened. The top of the plate was separated from the backing 0·5 inch.

(See *Figs. 8, 9* and *14.*)

Round 5.

Second shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel plate. Time, 9:31:45 A. M.

Gun.—Six-inch B. L. R

The point of impact was 24 inches from the top and 24 inches from the right side of the plate.

The projectile entered and remained in the plate, broken into two pieces, with its base 9 inches beyond the surface of the plate.

The estimated penetration of the point was 26·32 inches.

A bulge was formed on the face of the plate 18·75 inches in diameter, with a regular and curling fringe about the hole 1·75 inches high.

No cracks.

When the plate was removed from the backing the projectile was found broken at the rotation band, the head sticking in the backing and the base in the plate.

The bulge in the back of the plate was 17 inches in diameter and 4·5 inches high.

The indent in the backing corresponded in shape to the back bulge, was 11 inches in diameter and 4 inches deep. Two small fragments of the plate adhered to the backing.

The upper part of the plate was sprung away from the backing 0·5 inch.

(See *Figs. 10, 11* and *14.*)

Round 6.

Second shot at Bethlehem Iron Company's low-carbon steel Harvey plate. Time, 9:41:20 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the right side of the plate.

The projectile entered and broke up, the head with a very jagged fracture remained in the plate. The body of the shell broke into many fragments. The front end of the charge chamber was 2·37 inches inside the face of the plate.

The estimated penetration of the point was 9·7 inches.

A bulge was formed on the face of the plate 18 inches in diameter with a maximum height about the hole of one inch. There was no curling fringe, but the metal about the hole was chipped off. A crack probed 5 inches deep, but was probably through, and extended from the hole to the right side of the plate 18·37 inches from the top.

The bulge on the back of the plate was 18 inches in diameter and 1·62 inches high with a star of cracks opening out from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and one inch deep.

Several of the side plate bolts were started and loosened and the upper left corner of the plate was sprung away from the backing 0·25 inch.

(See *Figs. 12, 13* and *14.*)

A crack formed from point of impact to right hand edge which subsequently developed into a large through crack.

Round 7.

Third shot at Bethlehem Iron Company's high-carbon nickel-steel plate. Time, 9:53:20 A. M.

Gun.—Six-inch B. L. R.

The point of the impact was 24 inches from the bottom and 24 inches from the left side of the plate.

The projectile entered and rebounded unbroken to the front 15 feet, ricocheted 10 feet 6 inches farther, striking an oak timber and rebounded 7 feet. It was shortened 0·06 inch, expanded at bourrelet 0·02 inch, at body 0·035 inch, at base 0·0 inch.

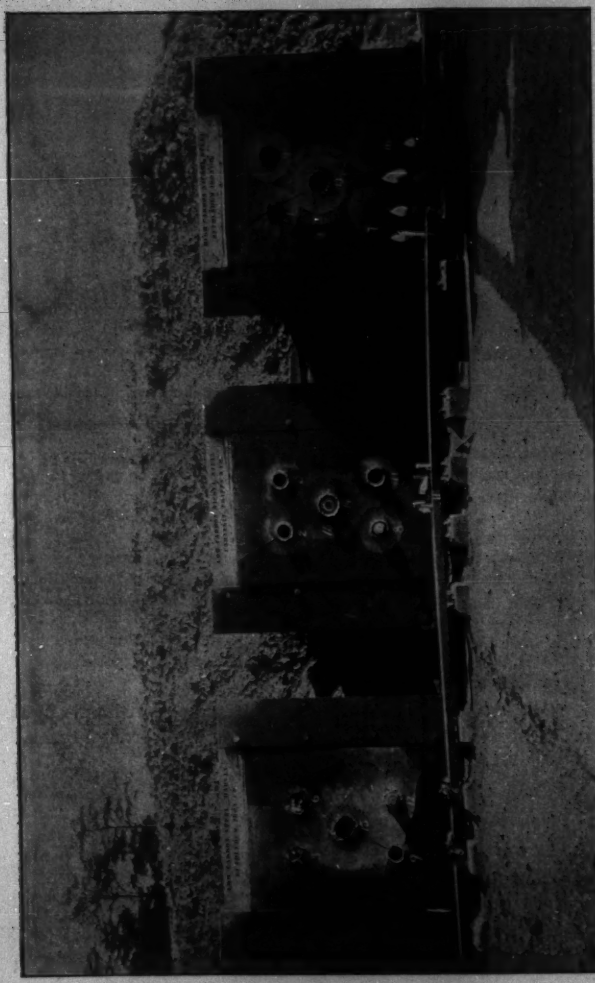


FIG. 14.—Targets after Round 15. (First day, October 31, 1891.)

The penetration of the point was 12·75 inches.

A bulge was formed on the face of the plate 16·75 inches in diameter, with a regular and curling fringe 1·75 inches high around the hole, with three radial hair cracks in the bulge, each 3 inches long.

The bulge on the back of the plate was 15 inches in diameter and 2·75 inches high, about the hole 0·5 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge, and was 11 inches in diameter and 2 inches deep.

Several bolts of the side plates were started and loosened.

The top of the plate was sprung from the backing 0·75 inch.

(See *Figs. 8, 9* and *14*.)

Round 8.

Third shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel plate. Time, 10:2:32 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the left side of the plate.

The projectile entered and remained in the plate apparently intact. The base plug could be turned while the projectile was warm, but when cold was set fast. The base of the projectile projected 2·69 inches from the face of the plate.

The estimated penetration of the point was 14·6 inches.

A bulge was formed on the face of the plate 16·5 inches in diameter, with a regular and curling fringe about the hole 1·44 inches high.

No cracks.

The bulge on the back of the plate was 17 inches in diameter and 4·25 inches high, about the hole 2 inches wide which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2·75 inches deep.

The top of the plate was sprung 0·75 inch away from the backing.

(See *Figs. 10, 11* and *14*.)

Round 9.

Third shot at Bethlehem Iron Company's low-carbon steel Harvey plate. Time, 10:10:45 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the left side of the plate.

The projectile entered and remained apparently intact in the plate, the base 9·68 inches inside the face.

The estimated penetration of the point was 26·96.

A bulge was formed on the face of the plate 16·25 inches in diameter, with a fringe about the hole 1·3 inches high, part of which was chipped off, and numerous radial hair cracks in the bulge not over 3 inches long.

The bulge on the back of the plate was 18 inches in diameter and 3·5 inches high about the hole through which the projectile had passed.

A crack extended from the hole to the bottom of the plate 24 inches from the left side, which probed 2·37 inches deep. The crack noted in No. 2 shot on this plate opened slightly and a surface crack developed upwards from No. 2 hole towards the top of the plate.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 2·5 inches deep. The projectile remained in the backing, its base projecting 1·5 inches from the surface.

The lugs of the wrought-iron clamp which held the bottom of the side plates were bent outwards and the right one cracked, showing that the side plates had been forced outward at the moment of firing.

(See *Figs. 12, 13* and *14.*)

Round 10.

Fourth shot at Bethlehem Iron Company's high-carbon nickel-steel plate. Time, 10:18:52 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the right side of the plate.

The projectile entered, broke into several pieces and rebounded, the head being found 21 feet to the front.

The penetration of the point was 10·37 inches.

The bulge was formed on the face of the plate 17·25 inches in diameter, with a regular and curling fringe about the hole 1·87 inches high, and two radial hair cracks in the bulge 3 and 4 inches long.

The bulge on the back of the plate was 15 inches in diameter and 1·62 inches high, with a slight crack from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 10 inches in diameter and one inch deep.

The side plate bolts were started and the upper part of the plate was 0·75 inch away from the backing.

(See *Figs, 8, 9* and *14.*)

Round 11.

Fourth shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel plate. Time, 10:26:55 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the right side of the plate.

The projectile entered, broke into several pieces, and rebounded, the head and a portion of the body in one piece being found 29 feet 6 inches to the front and 25 feet to the right. The head parted from the body at the bourrelet for about 300° with a single piece of the body about 4 inches long adhering thereto.

The penetration of the point was 13·19 inches.

The bulge was formed on the face of the plate 17·5 inches in diameter, with a regular and curling fringe about the hole 1·75 inches high.

No cracks.

The bulge on the back of the plate was 18 inches in diameter and 2·87 inches high about the hole 2 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2·5 inches deep, with a small fragment of the plate sticking therein. The course of backing next to the plate was split between No. 3 and No. 4 hole.

(See *Figs. 10, 11* and *14.*)

Round 12.

Fourth shot at Bethlehem Iron Company's low-carbon steel Harvey plate. Time, 10:36:50 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the right side of the plate.

The projectile entered and remained in the plate very much set up, the base projecting 6·37 inches from the face of the plate. The projectile near the bourrelet was expanded one inch, and there were two longitudinal cracks in the body; the base plug could be easily turned.

The estimated penetration of the point was 10 inches.

A bulge was formed on the face of the plate 16·25 inches in diameter and 1·5 inches high, much of the metal about the hole being chipped off.

A crack extended from No. 3 hole to the bottom of the plate 3·75 inches from the right side, which probed from 3 to 4·5 inches deep. A second crack extended from No. 4 hole vertically downwards and joined the last. Small surface cracks 15 inches long developed from hole No. 3.

The bulge on the back of the plate was 16 inches in diameter and 2 inches high with a star or cracks opening out from the point of the projectile.

The indent of the backing corresponded in shape to the back bulge, and was 12 inches in diameter and one inch deep.

(See *Figs. 12, 13* and *14.*)

Round 13.

Fifth shot at Bethlehem Iron Company's high-carbon nickel-steel plate. Time, 1:27 P. M.

Gun.—Eight-inch B. L. R.

Projectile.—Firminy armor-piercing shell of 210 pounds. The point of impact was the centre of the plate. The projectile entered the plate and rebounded apparently intact 25 feet to the front, struck an oak timber, then ricocheted 29 feet farther, striking bank and rebounded 8 feet. It was shortened 0·12 inch, expanded at bourrelet 0·00 inch, at body 0·06 inch, at base 0·01 inch.

The penetration of the point of the projectile was 16·5 inches.

A bulge was formed on the face of the plate 20·75 inches in diameter, with a regular and curling fringe around hole 2·12 inches high. A wide crack radiated from this by No. 1 hole to the top of the plate 12·25 inches from the left-side, another through No. 3 hole to the bottom of the plate

10·12 inches from its left side, and another to the No. 2 hole, all of which extended through the plate.

The bulge on the back of the plate was 22 inches in diameter and 5·5 inches high about the ragged hole 4·5 inches wide, made by the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 15 inches in diameter and 4 inches deep, with the imprint of the point of the projectile sharply defined, 5·62 inches deep.

The entire target structure was set back about an inch, the bolts of the side plates loosened and one of the backing bolts set back 4·5 inches. The top of the plate was sprung away from the backing 0·87 inch.

When the plate was removed from the backing it held together and all the armor bolts but three were easily unscrewed.

(See *Figs. 8, 9* and *14.*)

A comparison with the Creusot nickel-steel plate tested at Annapolis in 1890 is interesting at this point.*

By comparing *Figs. 6* and *7* and *Figs. 8, 9* and *14*, it will be observed that while the Creusot plate developed no cracks, the bulges at the back were much larger, the point of the eight-inch projectile passing entirely through the body, lodging in the plate. (*Plate I.*) On the other hand the Bethlehem plate, although developing a bad through crack, showed more resistance and a remarkable amount of elasticity.

Round 14.

Fifth shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel plate. Time, 1:38:20 P. M.

Gun.—Eight-inch B. L. R.

Projectile.—Firminy armor-piercing shell of 210 pounds.

The point of impact was the centre of the plate.

The projectile entered and remained in the plate apparently intact, with its base 0·87 inch inside the face of the plate.

The estimated penetration of the point was 22·08 inches.

A bulge was formed on the face of the plate 21 inches in diameter, with a regular and curling fringe about the hole 1·87 inches high.

A through crack extended from this to No. 1 hole and thence to the top of the plate 10·5 inches from the left side.

The back of the plate showed, in addition, a through crack from No. 5 through No. 4 hole to the bottom of the plate, and a very fine crack, not through, from No. 5 through No. 2 hole to the upper edge of the plate 11 inches from the right corner.

* The dimensions of this plate were exactly the same as those under consideration, viz: 8 x 6 feet x 10¼ inches.

The bulge on the back of the plate was 24 inches in diameter and 6·5 inches high about the projectile.

The indent in the backing corresponded in shape to the back bulge, was 14 inches in diameter, and the imprint of the point of the projectile was 10·75 inches deep.

Five of the backing and one of the armor bolts were started.

When the plate was removed from the backing it held together and all the armor bolts but two were easily unscrewed.

(See *Figs. 10, 11* and *14.*)

It will be noticed that the resistance of the upper part of this plate is much less (about half) than the middle and lower parts. The probable causes of this peculiarity will be discussed further on.

Round 15.

Fifth shot at Bethlehem Iron Company's low-carbon steel Harvey plate. Time, 1:46 P. M.

Gun.—Eight-inch B. L. R.

Projectile.—Firminy armor-piercing shell of 210 pounds.

The point of impact was the centre of the plate.

The projectile perforated the plate and remained, apparently intact, in the backing, the base 22·25 inches inside the face of the plate.

The estimated penetration of the point was 43·48 inches.

A bulge was formed on the face of the plate 22·5 inches in diameter and 1·25 inches high; the metal about the hole was chipped off.

A through crack reached from No. 2 to No. 3, passing through No. 5 hole, and all the previous cracks widened and some were much extended.

The bulge on the back of the plate was 24 inches in diameter and 8·37 inches about the hole through which the projectile had passed. The back of the plate showed in addition the following cracks, which extended partly through the plate: One from No. 5 to No. 4 hole, and three from No. 1 hole, the first to the top of the plate 13·5 inches from the left side; the second to the left side, 10 inches from the top; and the third to No. 5 hole.

The imprint in the backing corresponded in shape to the back bulge, and was 15 inches in diameter. The projectile remained in the backing.

The backing was split and broken through in wake of the shot. The side plates were started away one inch at the top, and several of the backing-bolts were driven back.

When the plate was removed from the backing it held together, and ten of the armor-plate bolts could not be unscrewed.

(See *Figs. 12, 13* and *14.*)

At this point a comparison with *Fig. 5*, which shows the compound Cammell plate tested at Annapolis, 1890, would be of interest.

In the case of the compound plate we have a hard steel face *welded* to a wrought iron back and in the Bethlehem plate a hard steel face produced by a chemical (cementation) treatment of the face of a solid steel plate. The properties of the two plates are therefore more or less similar inasmuch as each has a hard steel face, but the vast superiority of one over the other is manifest. All the projectiles *perforated* the compound plate, whilst none but the eight-inch got through the Bethlehem plate.

The accompanying table shows the comparative resistance of the four nickel-steel plates, viz: Creusot (Schneider & Co.), Bethlehem, the *low-carbon*, Carnegie, Phipps & Co., and the *high-carbon*, Carnegie, Phipps & Co. The terms high- and low-carbon used here are relative, the Creusot plate being considered, the author believes, a high-carbon plate. The public were informed that "high-carbon" meant about 0·4 per cent., and "low-carbon" 0·25 per cent., the content of nickel varies from 2 to 3·5 per cent.

The low-carbon plate contained about half as much carbon as the high-carbon plate, as will be seen from the following analysis of the Carnegie, Phipps & Co. low-carbon plate:

	I.	II.
Carbon,	= 0·26	
Phosphorous,	= 0·072	0·071
Manganese,	= 0·789	—
Silicon,	= 0·050	—
Nickel,	= 2·67	2·55
Sulphur,	= 0·013	—
Specific gravity,	= 7·822	—

A comparison of the analysis of the nickel-steel deck plate on p. 427, will be of interest at this point.

It must be understood in comparing the merits of the above American plates that these trials were not intended to determine which of the two steel works could produce the best plate, but to determine what *particular kind of plate* would give the best results under the same conditions, Neither company, the author understands, is an advocate for any one particular kind of plate, but make whatever the Government specify, whether it be high- or low-carbon

steel or nickel-steel, Harvey treated or Tresidder treated, The accompanying table shows the Bethlehem plate to have developed more resistance than the Creusot plate, although the latter showed no cracks at the end of the trials. The penetrations and back bulges were as regular on one plate as on the other, showing the relative resistance of the different parts of each plate to have been fairly uniform. The Carnegie plate showed unmistakable evidences of a comparative softness at the top where, rather strangely, after the fifth shot its only through crack was developed.

Another point in favor of this Bethlehem plate should be taken in consideration. The Bethlehem Iron Company were not only inexperienced in the manufacture of armor-plates, but these Indian Head trials were much more severe on the plates than were the Annapolis trials of 1890, while most of the conditions were the same, they differed in one very important particular, viz: the interval of time between the firing of the six-inch and the eight-inch shots. It is well known to physicists and engineers that when severe strains have been set up in large masses of metal they can be very sensibly reduced by allowing the metallic mass to remain perfectly quiet and free from strains for a considerable interval of time. If this theory be correct, and the author has no doubt that it is, it would be only reasonable to expect that the strains set up by firing a six-inch projectile into each of the four corners of a plate would be materially reduced by allowing the plate to stand several days before an eight-inch projectile was fired into the centre. This was the case at the Annapolis trials, when an interval of two days elapsed between the firings of the six-inch and eight-inch projectiles. At the Indian Head trials, however, this interval was about two hours, and the author feels quite certain that the metal in the plates had not even reached its normal temperature before the eight-inch projectiles were fired.

The author called attention to this fact (*i. e.*, he believes it to be a fact) a few days after the first of these trials,* and has since had no reason to change his views.

* The *Bulletin Am. Iron and Steel Association*, November 11, 1891, p. 329.

SECOND DAY, NOVEMBER 14, 1891.

Weather clear. Thermometer at 9 A. M. 49° F.; at 1 P. M., 69° F.

Round 1.

First shot at Carnegie, Phipps & Co.'s high-carbon nickel-steel plate. Time, 9:8:30 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the left side of the plate.

The projectile entered and rebounded 46 feet 6 inches to the front, burying itself in the sand. A circumferential hair crack was found near the bourrelet and the projectile was shortened 0·1 inch and expanded at bourrelet 0·0 inch, at body 0·04 inch, at base 0·0 inch.

The penetration of the point of the projectile was 12·5 inches.

A bulge was formed on the face of the plate 18·5 inches in diameter, with a chipped fringe 2 inches high about the shot hole, and a number of radial hair cracks in bulge not exceeding 3 inches long.

The bulge on the back of the plate was 14·5 inches in diameter and 3·56 inches high about the hole, 2·5 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 13 inches in diameter and 2·62 inches deep.

Two of the side-plate bolts were started.

(See *Figs. 15, 16* and *22*.)

Judging from the effect of the projectiles, the amount of carbon in this plate must have been much greater than the the other two nickel-steel plates.

By comparing *Fig. 6* with *Figs. 8* and *10*, it will be noted that there is an extensive fringe around each of the points of impact in Bethlehem and Carnegie, Phipps & Co. low-carbon nickel-steel plates, showing the metal to be ductile and elastic. The Creusot plate of the Annapolis trials, however, resembled the Carnegie, Phipps & Co. high-carbon nickel-steel plate under consideration more in this particular. The metal, instead of curling up in a regular fringe, chipped and flaked off like the excessively hard face of a Harvey-treated or compound plate.

Round 2.

First shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel Harvey plate. Time, 9:18:20 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the left side of the plate.

The projectile entered and remained apparently intact in the plate, the base projecting 2·62 inches from the face of the plate, the axis slightly inclined from the normal. A very small piece was found broken off from the extreme point of the projectile and two flakes were started from the head, half-way between the point and the bourrelet, adhering firmly at their rear ends.

The penetration of the projectile was 14·6 inches, the axis slightly inclined to the normal.

A bulge was formed on the face of the plate 18 inches in diameter, with a chipped fringe about the projectile 2·37 inches high, and a number of radial hair cracks in the bulge not over 4 inches long.

The bulge on the back of the plate was 21·5 inches in diameter and 4·12 inches high, with a star of cracks opening from the hole 5·5 inches wide through which the point of the projectile had passed.

The indent in the backing was jagged, 4 inches deep at centre and 14 inches in diameter. A small fragment of the plate adhered thereto.

One of the side-plate bolts was started.

(See *Figs. 17, 18* and *22.*)

A through crack developed at this point after the fifth shot.

Round 3.

First shot at Bethlehem Iron Company's high-carbon nickel-steel Harvey plate. Time, 9:26:56 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the left side of the plate.

The projectile entered the plate, broke into 3 pieces, and rebounded, the largest piece being found 45 feet to the front and 10 feet 6 inches to the right. One piece was the point 3 inches long, another, longitudinal, extending from the base 7 inches and 5 inches wide; the remaining piece was somewhat cracked. The projectile was expanded at bourrelet 0·03 inch.

The penetration of the point was 12 inches.

A bulge was formed on the face of the plate 18·25 inches in diameter with a chipped fringe about the hole 1·12 inches high, and a number of radial hair cracks in the bulge not over 5 inches long.

The bulge on the back of the plate was 21 inches in diameter, and 2·25 inches high about the hole 0·25 inch wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 1·5 inches deep.

The head of one of the side plate bolts was broken and two others loosened.

(See *Figs. 19, 20, 21* and *22.*)

Round 4.

Second shot at Carnegie, Phipps & Co.'s high-carbon nickel-steel plate. Time, 9:38 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the right side of the plate.

The projectile entered the plate, broke into many small pieces and rebounded. The head about 10 inches long was recovered, fracture jagged and parallel to the bourrelet.

The penetration of the point was 10·75 inches.

A bulge was formed on the face of the plate 19·75 inches in diameter with a curling fringe, partly chipped off about the hole 1·56 inches high, and a few radial hair cracks in the bulge not over 3 inches long.

The bulge on the back of the plate was 15 inches in diameter, and 1·94 inches high about the hole 1·25 inches, which opened out with a star of cracks from the point of the projectile. Three large pieces of the bulge were broken off.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 1·62 inches deep. A fragment of the plate 9 x 4 x 2·5 inches adhered to the backing.

(See *Figs. 15, 16* and *22.*)

Round 5.

Second shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel Harvey plate. Time, 9:41:15 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the right side of the plate.

The projectile entered and remained apparently intact in the plate, the base projecting 2·44 inches from the face of the plate, the axis slightly inclined to the normal.

The estimated penetration of the point was 14·86 inches.

A bulge was formed on the face of the plate 15·5 inches in diameter, with a ragged fringe about the hole 2 inches high and a number of radial hair cracks in the bulge not over 4 inches long.

A bulge on the back of the plate was 22 inches in diameter and 4·75 inches high about the hole 5·12 inches wide, which opened out with a star of deep cracks from the point of the projectile.

The indent in the backing was jagged, corresponding in shape to the back bulge, 11 inches in diameter and 4 inches deep. The course of the backing next to the plate was split between shot holes No. 1 and No. 2.

One of the side plate bolts was started.

(See *Figs. 17, 18* and *22.*)

Round 6.

Second shot at Bethlehem Iron Company's high-carbon nickel-steel Harvey plate. Time, 9:48:40 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the top and 24 inches from the right side of the plate.

The point of the projectile entered and remained in the plate, presenting

an appearance of being welded therein, the end of the chamber 0·5 inch outside of the plate; the body and base were broken into many small fragments, none of which were recovered.

The estimated penetration of the point was 6·82 inches.

A bulge was formed on the face of the plate 12·75 inches in diameter. Near the head of the projectile the metal of the plate was dished in and scarcely distinguishable from that of the projectile remaining in the plate. A few short radial hair cracks were in the bulge.

The bulge on the back of the plate was nearly imperceptible, but was found to be 18 inches in diameter and 0·25 inch high.

No cracks.

There was a discoloration of the backing opposite the back bulge but no indent.

A head of one of the side plate bolts was broken.

(See *Figs. 19, 20, 21* and *22*.)

Round 7.

Third shot at Carnegie, Phipps & Co.'s high-carbon nickel-steel plate. Time, 9:55:40 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the left side of the plate.

The projectile entered the plate and rebounded, broken into several large and a number of small pieces; some of the former recovered, among which was half of the head, which had been split longitudinally.

The penetration of the point was 12 inches.

A bulge was formed on the face of the plate 19·25 inches in diameter, with an irregular curling fringe partly chipped off about the hole 1·75 inches high, and a few radial hair cracks in the bulge.

A through crack extended from this hole to the bottom of the plate 28·75 inches from the left lower corner, which was sprung out about 0·5 inch.

The bulge on the back of the plate was 16 inches in diameter and 2·37 inches high about the hole 2 inches wide, which opened out with a star of cracks from the point of the projectile; about half of the bulge was broken out to a depth of about 1·5 inches.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 2·5 inches deep. One small fragment of the plate was imbedded in the backing.

(See *Figs. 15, 16* and *22*.)

Round 8.

Third shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel Harvey plate. Time, 10:2:15 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the left side of the plate.

The projectile entered the plate and rebounded to the front 12 feet 6 inches, and thence ricocheted 35 feet 2 inches beyond. It was considerably

upset, being shortened 2·09 inches and expanded at the bourrelet 0·86 inch, at the body 0·58 inch, and at the base 0·01 inch. A number of small thin pieces flaked off the head.

The penetration of the point was 9·75 inches.

A bulge was formed on the face of the plate 16·75 inches with an irregular, ragged, curling fringe 2·25 inches high about the hole and a number of radial hair cracks in the bulge not over 4 inches long.

The bulge on the back of the plate was 19·5 inches in diameter and 1·81 inches high about the hole 1·25 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge, and was 11 inches in diameter and 1·37 inches deep.

(See *Figs. 17, 18* and *22.*)

Round 9.

Third shot at Bethlehem Iron Company's high-carbon nickel-steel Harvey plate. Time, 10:9:30 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the left side of the plate.

The projectile entered the plate and rebounded 37 feet 10 inches to the front and thence ricocheted 19 feet farther. The projectile was unbroken, but there was a longitudinal crack from bourrelet to band score. It was shortened 0·14 inch and expanded at bourrelet 0·015 inch, at body 0·05 inch, at base 0·01 inch.

The penetration of the point was 12·25 inches.

A bulge was formed on the face of the plate 18 inches in diameter, with an irregular chipped fringe about the hole 1·5 inches high, and a number of radial hair cracks in the bulge not over 5 inches long. There were also three deeper radial cracks—two 6 inches, and one 5·5 inches long.

The bulge on the back of the plate was 15·25 inches in diameter and 2·12 inches high near the hole one inch wide which opened out with a star of racks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 12 inches in diameter and 1·25 inches deep.

One of the backing bolts was started back 1·5 inches.

(See *Figs. 19, 20, 21* and *22.*)

Round 10.

Fourth shot at Carnegie, Phipps & Co.'s high-carbon nickel-steel plate. me, 10:16:50 A. M.

Gun—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from he right side of the plate.

The projectile entered the plate and rebounded 47 feet 10 inches to the front; in it were two longitudinal cracks, one from the bourrelet to the base apparently a through crack, and the other extending from the bourrelet to the band score.

The projectile was shortened 0·11 inch and expanded at the bourrelet 0·03 inch, at the body 0·08 inch, and at the base 0·02 inch.

The penetration of the point was 11·87 inches.

A bulge was formed on the face of the plate 18 inches in diameter with a curling fringe about the hole, partly chipped off, 1·87 inches high, and several radial hair cracks in the bulge not over 3 inches long.

One through crack extended from this through No. 3 hole to the side of the plate, 35·5 inches from the left lower corner, and the one mentioned in round 7 was slightly opened.

The bulge on the back of the plate was 20 inches in diameter and 2·87 inches high around the hole, 2·65 inches wide, opening out with a star of cracks from the point of the projectile.

The indent in the backing corresponded in shape to the back bulge and was 11 inches in diameter and 2 inches deep, with a small fragment of the plate sticking therein.

Both of the lugs of the bottom clamp holding the side plates were cracked. (See *Figs. 15, 16* and *22.*)

Round 11.

Fourth shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel Harvey plate. Time, 10:23:17 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the right side of the plate.

The projectile entered and remained apparently intact in the plate, with the base 3·3 inches inside the face.

The penetration of the projectile was 20·5 inches.

A bulge was formed on the face of the plate 16·5 inches in diameter, with a broken curling fringe about the hole 2 inches high and a few radial hair cracks in the bulge about 3 inches in length.

The bulge on the back of the plate was 18 inches in diameter and 4·62 inches high about the projectile, with a star of cracks extending therefrom.

The indent on the backing was a jagged hole 12 inches in diameter corresponding to the back bulge, with the imprint of the point of the projectile 10 inches deep and two small fragments of the plate sticking therein.

(See *Figs. 17, 18* and *22.*)

Round 12.

Fourth shot at Bethlehem Iron Company's high-carbon nickel-steel plate. Time, 10:30:12 A. M.

Gun.—Six-inch B. L. R.

The point of impact was 24 inches from the bottom and 24 inches from the right side of the plate.

The point of the projectile entered and remained in the plate, presenting an appearance of being welded therein, the end of the chamber being level the face of the plate. The base and body of the projectile were broken into many small fragments.

The estimated penetration of the point was 7·32 inches.

A bulge was formed on the face of the plate 13·75 inches in diameter. Near the head of the projectile the metal of the plate was dished in and scarcely distinguishable from that of the projectile remaining in the plate. A few radial hair cracks were in the bulge, of varying lengths, none over 6 inches, and a few pieces of metal were scaled off in the bulge.

The bulge on the back of the plate was nearly imperceptible, but was found to be 17 inches in diameter and 0·31 inch high.

No cracks.

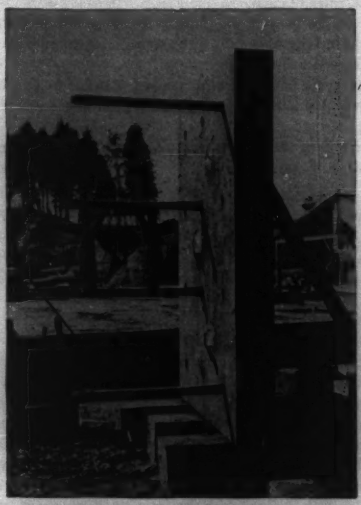


FIG. 21.—Harvey high-carbon nickel-steel, Bethlehem.

There was a discoloration of the backing opposite the back bulge, but no indent.

(See *Figs. 19, 20, 21* and *22.*)

Round 13.

Fifth shot at Carnegie, Phipps & Co.'s high-carbon nickel-steel plate. Time, 12.9:48 P. M.

Gun.—Eight-inch B. L. R.

Projectile.—Eight-inch Carpenter armor-piercing shell of 250 pounds.

The point of impact was the centre of the plate.

The projectile entered and rebounded 6 feet 3 inches to the front, very much set up and cracked. The cracks were generally longitudinal, and

many thin pieces flaked off from the head. The projectile was very hot and was still warm an hour after. It was shortened 3·58 inches, and expanded at bourrelet 1·65 inches, at the body 0·97 inch, at the base 0·28 inch.

The penetration of the point was 9·62 inches.

A bulge was formed on the face of the plate 20 inches in diameter, with an irregular fringe about the hole 1·75 inches high and a few radial hair cracks in the bulge.

A through crack extended from the No. 3 through No. 5 and No. 2 holes to the right side of the plate, 7 inches from the top, and those developed at No. 3 and No. 4 shots were somewhat opened.

In addition to the through cracks on the face of the plate, the following, extending nearly through the plate, were found on the back: One from No. 5 through No. 1 hole to the top of the plate; 15·5 inches from the left upper corner, and one from No. 4 hole to the right side of the plate 18 inches from the right lower corner.

The bulge on the back of the plate was 25 inches in diameter and 1·56 inches high, about the hole 1·25 inches wide, which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded to the back bulge and was 13 inches in diameter and one inch deep.

The middle armor bolt of the second row from the bottom was broken at the plate and thrown 2 feet to the rear; both of the lugs of the bottom clamp for the side plates were broken. The backing structure was set back 0·5 inch, and the course of backing next to the plate was split.

When the plate was removed from the backing the left lower corner separated from the remainder of the plate. The armor bolt above No. 5 hole stuck in the plate; the one below it was broken off flush with the back of the plate; the remaining bolts were easily unscrewed.

The top of the plate was after the firing sprung 0·25 of an inch away from the backing.

(See *Figs*, *15*, *16* and *22*.)

This was the first time American projectiles were used at these trials, and it must in truth be admitted they were not up to the standard. Any one familiar with the subject knows how difficult it is to make an efficient a. p. projectile, and it can hardly be expected that the Carpenter Steel Company, having so recently domesticated the Firminy process at their works at Reading, Pa., could produce, with such a short experience, results as good as those produced abroad after years of trial and experiment.

The fact the projectile was so hot after striking the plate, shows very conclusively that a very large proportion

of the work was expended upon it instead of the plate, as should be the case with the best projectiles.

Round 14.

Fifth shot at Carnegie, Phipps & Co.'s low-carbon nickel-steel Harvey plate, Time, 12:19:50 P. M.

Gun.—Eight-inch B. L. R.

Projectile.—Eight-inch Carpenter armor-piercing shell of 250 pounds.

The point of impact was the centre of the plate.

The projectile entered the plate, rebounded 33 feet to the front, broke into several pieces, the head being thrown 22 feet 10 inches to the front, and the body 33 feet to the right. The extreme point of the head was bruised and a piece chipped off.

The penetration of the point of the projectile was 17·25 inches.

A bulge was formed on the surface of the plate 18·5 inches in diameter, with an irregular broken fringe about the hole 2·5 inches high, and a few radial hair cracks in the bulge.

Through cracks extended from hole No. 5 through No. 1 to the top of the plate, 6·75 inches from the left upper corner; and through No. 3 to the bottom of the plate, 11 inches from the left lower corner; a deep crack extended from No. 5 to No 2 hole.

In addition to the through cracks on the face of the plate a crack reaching nearly through the plate extended on the back from No. 5 through No. 4 hole to the bottom of the plate, 14·25 inches from the right lower corner.

The bulge on the back of the plate was 26 inches in diameter and 6·75 inches high at the hole, 5·5 inches wide, which opened out with a star of cracks from the point of the projectile.

There was a jagged depression in the backing 16 inches in diameter and 5·5 inches deep, with a small fragment of the metal sticking therein. The course of the backing next to the plate was split in the line of the upper backing-bolts.

When the plate was removed from the backing it held together, and the bolts were easily unscrewed, excepting the one above and the one below No. 5 hole.

The top of the plate was, after the firing, sprung 0·25 inch away from the backing.

(See *Figs. 17, 18* and *22.*)

Round 15.

Fifth shot at Bethlehem Iron Company's high-carbon nickel-steel Harvey plate. Time, 12:37:33 P. M.

Gun.—Eight-inch B. L. R.

Projectile.—Eight-inch Firminy armor-piercing shell of 210 pounds.

The point of impact was the centre of the plate.

The projectile entered the plate and rebounded to the front 38 feet, then ricocheted violently against the timber protection of the gun, rebounding therefrom 6 feet. The projectile cracked longitudinally and flaked consider-

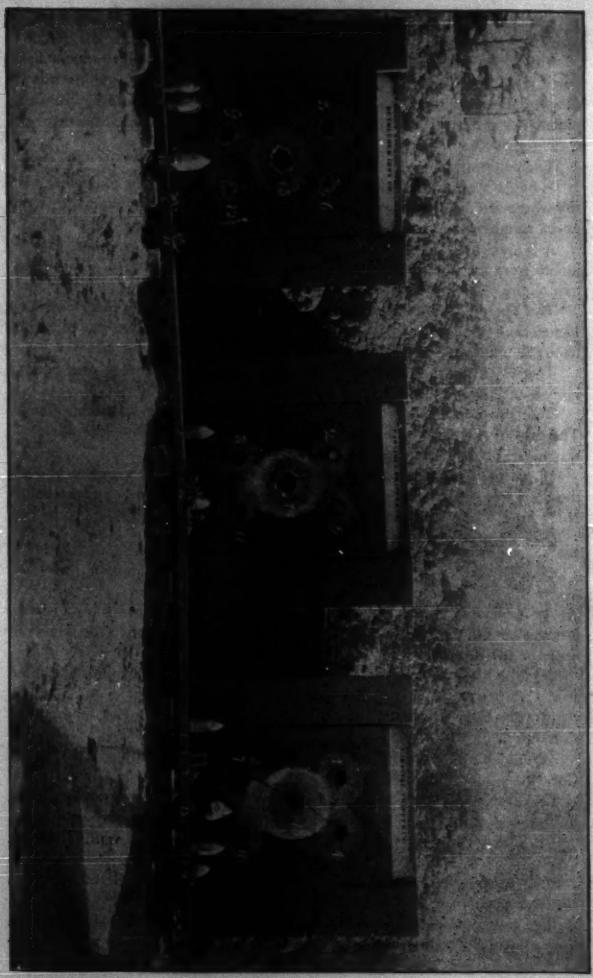
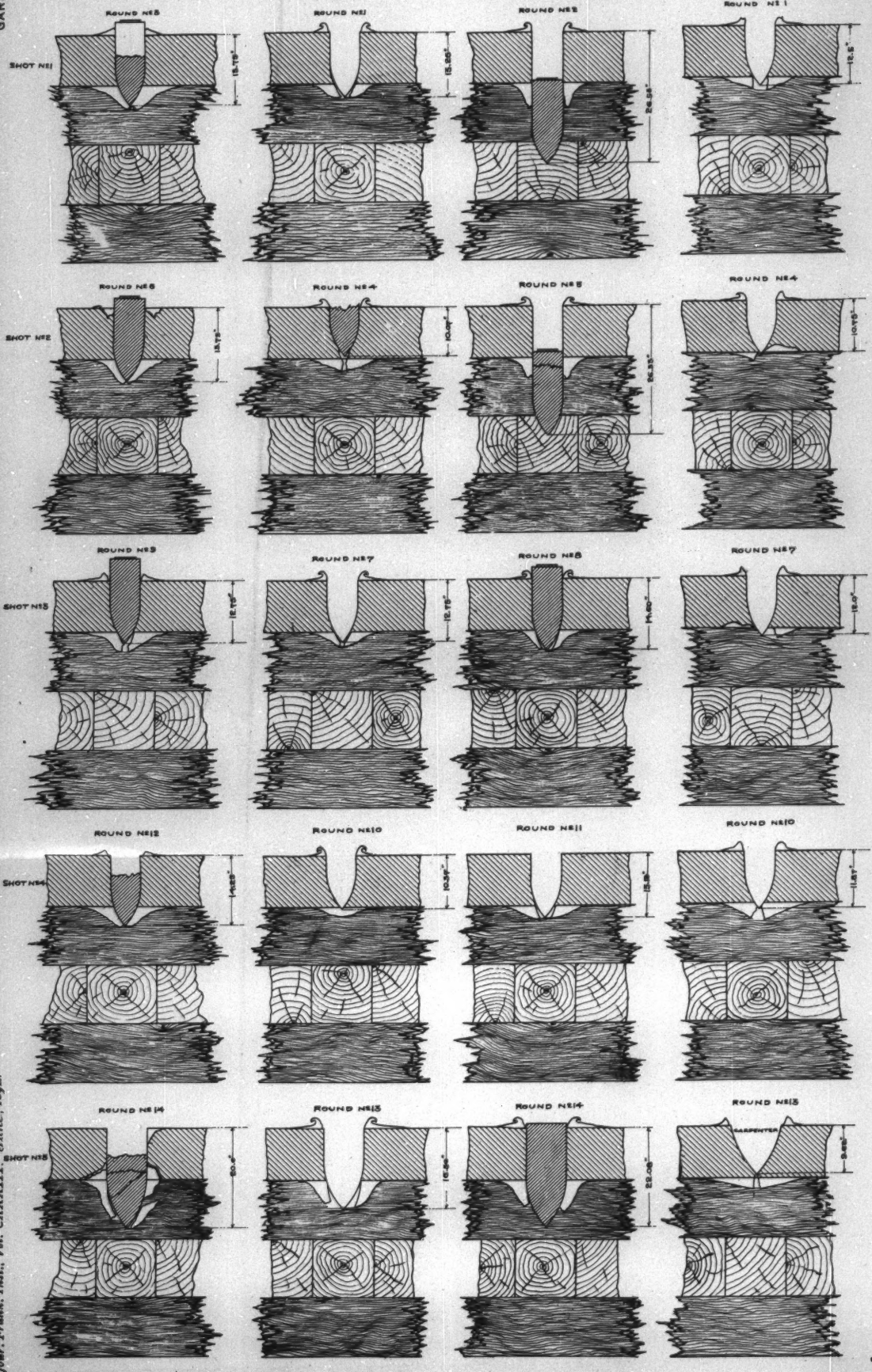


FIG. 22.—Targets after Round 15. (Second day, November 14, 1891.)

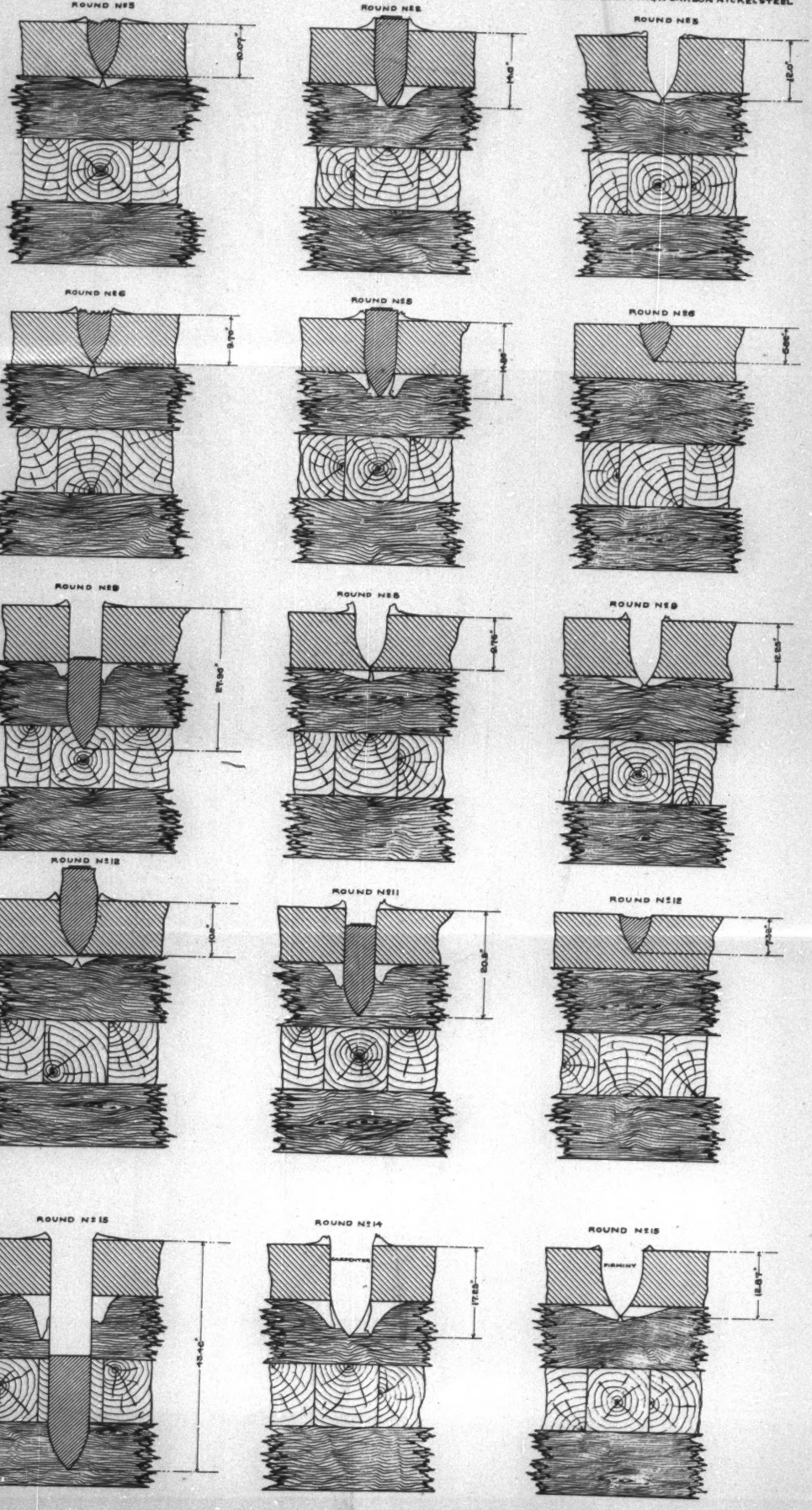
PENETRATIONS NICKEL STEEL PLATES

1	2	3	4
CREUSOT ANNAPOLIS TRIALS	BETHLEHEM HIGH CARBON	CARNEGIE LOW CARBON	CARNEGIE HIGH CARBON



PENETRATIONS HARVEY-TREATED PLATES

	1 BETHLEHEM LOW CARBON STEEL	2 CARNEGIE LOW CARBON NICKEL STEEL	3 BETHLEHEM HIGH CARBON NICKEL STEEL
SHOT №1	ROUND №5	ROUND №5	ROUND №5
SHOT №2	ROUND №6	ROUND №5	ROUND №6
SHOT №3	ROUND №9	ROUND №8	ROUND №9
SHOT №4	ROUND №12	ROUND №11	ROUND №12
SHOT №5	ROUND №15	ROUND №14	ROUND №15



NICKEL-STEEL PLATES.

Name of Plate.	Penetration of Point in Inches.					Bulge at Back.				
	No. of Six-inch Projectiles.				8-inch.	No. of Six-inch Projectiles.				Eight-inch.
	First.	*Second.*	*Third.*	*Fourth.*	*Fifth.*	*First.*	*Second.*	*Third.*	*Fourth.*	*Fifth.*
Creusot nickel-steel (Annapolis trials, 1890),	13·75	13·75	12·75	14·25	20·0	5 inches high and 21 inches diameter.	6 inches high and 21 inches diameter.	4 inches high and 19 inches diameter.	4 inches high and 18 inches diameter.	A crater formed 21 inches diameter.
Bethlehem nickel-steel plate, high-carbon,	13·25	10·07	12·75	10·37	16·50	1·75 inches high and 16·5 inches diameter.	2 12 inches high and 17 inches diameter.	2·75 inches high and 15 inches diameter.	1·62 inches high and 15 inches diameter.	5·5 inches high and 22 inches diameter.
Carnegie, Phipps & Co., nickel-steel plate, low-carbon,	26·53	26·33	14·60	13·19	22·08	4·87 inches high and 16·5 inches diameter.	4·5 inches high and 17 inches diameter.	4·25 inches high and 17 inches diameter.	2·87 inches high and 18 inches diameter.	6·5 inches high and 24 inches diameter.
Carnegie, Phipps & Co., nickel-steel plate, high-carbon,	12·5	10·75	12·0	11·87	9·62*	3·56 inches high and 14·5 inches diameter.	1·94 inches high and 15 inches diameter.	2·37 inches high and 16 inches diameter.	2·87 inches high and 20 inches diameter.	1·56 inches high and 25 inches diameter.

* Carpenter a. p. projectile.

STEEL AND NICKEL-STEEL PLATES—Treated by Harvey Process.

Name of Plate.	Penetration of Point in Inches.					Bulge at Back.				
	No. of Six-inch Projectiles.				8-inch.	No of Six-inch Projectiles.				Eight-inch.
	First.	*Second.*	*Third.*	*Fourth.*	*Fifth.*	*First.*	*Second.*	*Third.*	*Fourth.*	*Fifth.*
Bethlehem low-carbon steel, Harvey plate,	10·07	9·7	26·36	10·	43·48*	2 inches high and 16 inches diameter.	1 62 inches high and 18 inches diameter.	3·5 inches high and 18 inches diameter.	2 inches high and 16 inches diameter.	Projectile through hole, 24 inches diameter.
Carnegie, Phipps & Co low-carbon, *nickel-steel*, Harvey plate,	14·6	14·86	9·75	20·5	17·25†	4·12 inches high and 21·5 inches diameter.	4·75 inches high and 22 inches diameter.	1·81 inches high and 19·5 inches diameter.	4·62 inches high and 18 inches diameter.	6·75 inches high and 26 inches diameter.
Bethlehem high-carbon, *nickel-steel*, Harvey plate,	12·	6·82	12·25	7·32	12·87‡	2·25 inches high and 21 inches diameter.	0·25 inch high and 18 inches diameter.	2·12 inches high and 15·25 inches diameter	0 31 inch high and 17 inches diameter.	2·62 inches high and 23 inches diameter.

* Firminy a. p. shell (210 pounds).
† Carpenter a. p. shell (250 pounds).
‡ Firminy a. p. shell (210 pounds).
All the six-inch shells, Holtzer a. p. chrome.

ably at the rear of the head. On the body of the shell was a score which extended around the projectile at the section of a plane inclined to the axis.

This score could have been formed by a rotary motion against a hard point, combined with a movement forward and back, and possibly was so done by the rotation of the projectile on entering and rebounding from the plate. The projectile was shortened 1·36 inches, and expanded at the bourrelet 0·31 inch, at the body 0·41 inch, at the base 0·03 inch.

The penetration of the point was 12·87 inches.

A bulge was formed on the face of the plate 17 inches in diameter, with the fringe around the hole chipped off and nowhere higher than 0·94 inch, and a number of radial hair cracks in the bulge, none over 7 inches long.

A through crack extended through hole No. 1 to the top of the plate 14 inches from the left upper corner, and another through hole No. 3 to the bottom of the plate 17·5 inches from the left lower corner.

The bulge on the back of the plate was 23 inches in diameter and 2·62 inches high about a hole 0·5 inch wide which opened out with a star of cracks from the point of the projectile.

The indent in the backing corresponded to the back bulge and was 15 inches in diameter and 2 inches deep.

The course of backing next to the plate was split in line of backing bolts. The lugs of the lower side-plate clamp were cracked and the left side plate was moved 0·25 inch to the left.

When the plate was removed from the backing it held together, and all the bolts were easily unscrewed excepting four, one above and one below No. 5 hole, and one at upper and one at lower left corner.

(See *Figs. 19, 20, 21* and *22.*)

SUMMARY.

After careful consideration of the results of the firing upon the six plates, it is the unanimous decision of the Board that they be placed in the following order of merit, viz:

(1) The high-carbon nickel-steel Harvey plate furnished by the Bethlehem Iron Company.

(2) The high-carbon nickel-steel plate furnished by the Bethlehem Iron Company.

(3) The high-carbon nickel-steel plate furnished by Carnegie, Phipps & Co.

(4) The low-carbon nickel-steel Harvey plate furnished by Carnegie, Phipps & Co.

(5) The low-carbon nickel-steel plate furnished by Carnegie, Phipps & Co.

(6) The low-carbon steel Harvey plate furnished by the Bethlehem Iron Company.

The right side of the plate No. 1 showed very remarkable qualities. The two projectiles which struck that side penetrated not more than 7 inches, the head remaining in the plate completely filling the hole, and with the appear-

ance of having been welded to the surrounding metal, while the body was shattered into many fragments.

No cracks were made on that side of the plate.

The back of the plate on that side showed no disturbance except a hardly noticeable swelling on the surface.

It is to be noted that the upper part of plate No. 6 (Harveyed) showed qualities resembling those of the right side of No. 1, while, on the other hand, plate No. 4 (likewise Harveyed) was totally lacking in such characteristics.*

Plate No. 2 showed a great degree of uniformity as well as resistance to penetration.

The small penetration of the eight-inch shot in plate No. 3 is, in the opinion of the Board, due to the excessive upsetting of the projectile.

All of the armor-plates were more or less cracked through, but only two, Nos. 3 and 6, badly, and these two plates alone showed cracking before the fifth shot. Plates Nos. 1, 2 and 3 kept out all the projectiles; No 4 was perforated by one, and Nos. 5 and 6 by two projectiles each.

It will be noticed that the "high carbon" plates show better results than those of "low-carbon," but it is believed that the chemical anaylsis of the plates now in progress will show that the words "high" and "low," employed by the manufacturers, have been used arbitrarily and have but little value for purposes of comparison.

The Holtzer and Firminy projectiles were part of the lot used at the Annapolis armor trials of last year.

Comparing the plates of this trial with the Creusot steel and the Creusot nickel-steel plates of the Annapolis trials of September, 1890, the Board is of the unanimous opinion that—

No. 1, the high-carbon nickel-steel Harvey plate furnished by the Bethlehem Iron Company, and

No. 2, the high-carbon nickel-steel plate furnished by the Bethlehem Iron Company, are superior to the Creusot steel and nickel-steel plates of last year.

The following tables show the relative penetrations of the projectiles in the nickel-steel plates and in the several plates treated by the Harvey process.

In accompanying *Plates I* and *II*, we have these penetrations graphically illustrated. The penetrations in the Creusot nickel-steel plate of the Annapolis trials of 1890 are included.

[*To be continued*]

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* The method of tempering at Bethlehem differed from that at Pittsburgh. [Note by Department authority.]

EYESIGHT, IN MIDDLE LIFE AND OLD AGE, WITH A FEW HINTS FOR ITS CARE AND PRESERVATION.

By L. Webster Fox, M.D.

[*A lecture delivered before the Franklin Institute.*]

Members of the Institute, Ladies and Gentlemen:

Little more than a year ago I had the honor of appearing before the members of the Franklin Institute and their friends, to lecture on a subject of great importance to the growing child and youth.

The widespread interest which this lecture created not only in this country but abroad, its republication in scientific and abstracts from it by medical journals, has led me to think that that lecture has not been without its good results.

In that lecture I dealt with the care of vision during infancy and led up to adult life. Having considered these two periods and called attention to whatever may prove either injurious or beneficial to the eye, I now take up the thread of my discourse, and continue it up to old age.

If the eye of man has escaped the vicissitudes of youth, we find it at its best at about twenty years of age. Let the boy be brought up strong in mind and with a clear intellect, so that when he enters his twenty-first year he will have the physique to carry him through the life work which lies before him.

In this day of telegraphy, shorthand and specialism, man has much labor both mentally and physically to perform, and we must always remember that 'tis through the eye that the greater part of this labor is accomplished.

It is bound to excite astonishment at the wonderful labor-performing functions of an eye when we think of what can be done. The expenditure of eyesight means also the necessity of recuperation of the functions of the eye. If these functions are blunted by some toxic drug, the vision must necessarily become weakened and in some instances destroyed.

"Habit," says Schiller, "is the nurse of man." If boys bring with them up to the entrance of manhood habits which are pernicious, what a serious outlook for the lasting qualities of that individual who requires immense expenditure of nervous energy and eyesight between manhood and old age, or between twenty and sixty.

Some of you may remember that I closed my last lecture by suggesting some hints on the care of vision, and called attention to the habit of smoking, particularly. Tobacco and alcohol are the two most prominent agents which not only pervert but also destroy special senses, and of which men of this age too freely indulge, especially in social life. How guarded should the young man be that he does not fall into habits which cling to him through life like a leech!

It is a well authenticated fact that boys who have indulged in the use of tobacco are not mentally and physically as strong as those who abstain; not only have medical men recognized the tendency to a depression of the vital force in boys and young men who are constant users of tobacco, but athletic trainers will never select their boats' crew from such ranks.

These men know that tobacco weakens the heart. It is the same with foot-ball teams, or tug-of-war men; they may be giants of strength, but when the final test comes, that subtle fluid flying through their nerves with lightning-like rapidity, is suddenly snapped; collapse and defeat follow.

When such facts are known to non-medical men, no wonder that twenty-nine States have passed laws forbidding the sale of tobacco to boys.

I do not wish in a public lecture of this kind to speak of a great benefactor, but I must say that if any one man deserves the thanks of a generation, it is John H. Fow, of this city, for bringing about the law prohibiting the sale of cigarettes to boys.

The excessive use of tobacco not only weakens the muscles of the eye, but also produces a lowering of the acuity of vision and a form of color-blindness. I can recall an instance of this peculiar form of blindness.

Prof. Chisolm, of Baltimore, some years ago had a

patient, a planter's wife from one of the Southern States, consult him for defective vision, and who was also blind to certain colors. Prof. Chisolm, after making an examination with the ophthalmoscope, and who up to this stage of the examination had not asked her anything as to personal habits, turned to her and said, "If you were a man I should pronounce your case one of tobacco amblyopia, or color-blindness due to excessive use of tobacco." The lady, completely surprised at the keenness of the observation, confessed that she was an excessive smoker; she and her husband lived alone in a retired part of the country, and in the evening after dinner she would light her husband's pipe, at first taking but one whiff; as time went on she would increase the number of whiffs, until she gradually became addicted to the use of tobacco.

How often we hear of the sudden deaths of young men or individuals in the prime of life! Could we read between the lines, or in other words dissect that nervous system, we might read there, or find the evidence of over-indulgence in tobacco.

Dr. Martin, of Manchester, writes: "The injurious effects of smoking may not, except under very careful testing, become apparent for years. In many cases it may be difficult to prove that certain diseased conditions are chiefly or wholly attributable to smoking, but where our knowledge of disease processes is very exact, and especially where we have undoubted methods of testing the symptoms presented, the proof of the adverse action of a particular agent may be proved beyond doubt."

With smoking, I class the chewing of tobacco as a very grave evil. The filthy habit which compels street-car companies to exhibit placards in their cars prohibiting spitting, speaks in words stronger than I can use. It is a disgrace to American manhood that such a recourse had to be taken.

We read that Prof. Pfeiffer has discovered the bacillus of influenza in sputum. Is it surprising that influenza exists in this city when every street pavement or public building is one large cuspidore?

Let any one take a walk down Broad Street on a Sunday afternoon, or pass through the archways of our Public Buildings, and it makes one wish that we had a law prohibiting the sale and use of chewing tobacco and expectorating in public places. The chewing of tobacco as an indirect destroyer to vision ranks second to smoking, and every boy should be severely punished for using it.

One thing to which attention has been recently called is that the women of this generation are proportionately larger than men. If such is the fact may it not be due to women abstaining from the use of tobacco?

Large sums of money are voted and many laws passed for all kinds of sanitary precautions; medical colleges vie with each other in selecting the ablest and best instructors to guide medical students towards becoming the keen guardians of the public health, but what does it avail when these patent evils remain unfettered! Do not misunderstand my imputations against the use of tobacco; a large gulf lies between the use and abuse of the fragrant weed. Men who have gone through a certain amount of mental strain are the better for smoking one, two or three cigars daily; they have a soothing effect upon the over-wrought nervous system, and smoking brushes away the cobwebs and makes man a more sociable creature. Any excessive indulgence in smoking is sure to produce evil results, but the chewing of tobacco must be condemned at all times.

Another source of injury to vision is the excessive use of alcohol in whatever form it is taken into the system. The drinking of beer or wine acts in a deleterious manner upon that part of the eye called the crystalline lens.

Excessive wine and beer drinkers are very prone to have cataracts before they have passed the forty-fifth mile-post in their lives, while whiskey drinkers are subject to affections of the retina and optic nerve.

There are also certain drugs which produce a bad effect on vision. It is said that Americans are fast becoming a quinine-eating people. I do not wish for a moment to speak against any drug so important to the pharmacopœia, but I must enter my protest as an ophthalmic surgeon to the

indiscriminate use and abuse of this valuable therapeutic agent.

I am sure that certain intraocular affections may be traced to the abuse of this drug. I have in my possession the notes of several cases where blindness was directly traced to excessive doses taken at short intervals.

One of these patients had a very sad ending. This man spent several months in the Valley of the Amazon, and while there contracted ague. To break up the severe attacks of chills and fever, he was obliged to literally feed upon quinine. He continued this treatment until his eyesight began to fail, when, upon his return to this country, he consulted me about his blindness, but was already beyond ophthalmic aid. I could continue this chapter on the abuse of this invaluable drug, but I must pass on. Other drugs which are also injurous to eyesight are chloral, opium and the bromides.

Cosmetics which are placed in the eye to heighten its lustre should be avoided, as they are always dangerous; eye balms of all kinds should be avoided, especially if the ingredients are rich in the proportions of lead.

The same observations are applicable to the dyeing of the hair and eyebrows.

There is a case on record where a diminution of vision has been traced to the wearing of an artificial wreath of flowers.

In ancient Greece amd Rome, the business of painting the skin was a work of art, and ladies of wealth and fashion kept female slaves for the express purpose, but their paints consisted for the most part of the less injurious materials procured from the vegetable or animal kingdoms.

Another source of failing vision may be traced to impeded circulation. The wearing of tight neckwear, such as collars which are too small or shirt bands or neckties tightly drawn should be avoided, this prevents the downward column of blood returning to the heart; the blood being retarded is dammed up in the capillary blood vessels, the heart driving against this volume of blood is sure to cause dilatation of them and certain diseases develop. We

are almost sure to have fulness of the head or headache following. To say the least, the equilibrium of the circulation is destroyed.

The same rules hold good to constriction of other parts of the body.

A subject which is commanding some attention is, "Are type-writing machines injurious to vision?" The individuals who find the most trouble with their vision are those who are students at this new calling. Close attention and concentration of vision is necessary to produce accurate copy. After one becomes so thoroughly proficient in manipulating the keys that he acts automatically, much relief is given to the eyes, but until this is accomplished, a great many, especially young girls, suffer from eye strain.

I have given this matter considerable attention for a long time, and I am constantly consulted by individuals who earn a livelihood by working at such machines six to eight hours daily and in some cases longer, and I find that the arrangement of keys has much to do with those afflicted with ocular disorders, for they who wrote on machines having circular key-tips almost always had eye trouble.

Among the many patients who have consulted me, I quote from one who has been using various machines now on the market; his language is as follows:

"In considering the various type-writing machines now in use, and the effect they have on the eyesight of those using them, I will make use of but three; namely, the Remington, Caligraph and Hammond, as these are the leading machines and the ones most in use.

"The key-board of the Remington machine contains thirty-eight keys, circular in form, with the letters printed on white paper covered with glass. On account of their arrangement, shape, size and color, they are very confusing, having a tendency to run together.

"The Caligraph has this same fault in a much more aggravated form, from the fact of its having a larger number of keys, thus tending to add to the confusion or running tendency which a multiplicity of keys produces.

"The Hammond has its key-board arranged in the form

of a semi-circle, each key being made of ebony wood and shaped somewhat like a piano key, with the letter cut on them and filled with white enamel. The thirty keys represent, collectively, ninety characters, having fewer keys and more characters than any other machine, and yet the keys are made of such material, color and shape that they do not tire the eyes in using them."

This patient has been using type-writing machines almost constantly for the past five years; during the first two years he used a machine with round finger tips or keys, and he always experienced a burning sensation in the eyes as if small particles of sand had lodged under the lids; the smaller blood vessels looked congested and these symptoms became so aggravated that he consulted my assistant (I being in Europe at the time), to see if something could be done to relieve him from his misery. He could not read at night after working through the day. Prior to using this machine he had had no eye trouble of any kind. My assistant, who made a careful examination, found that he had no visual defect. He exchanged his type-writing machine, and after three years' constant use he has had no further trouble with his eyes.

Another patient, who has had a somewhat similar experience, tells me that while she has never used the Ideal Hammond, the black keys of the Caligraph are less hurtful to her eyes than the white keys of other machines.

Before a writer becomes so proficient that he can perform his work automatically, his eye strain must be enormous. If any visual defect exists I prescribe the proper glasses, and if round finger tips or keys are used I advise a change to be made to machines having rectangular keys, which I find are the least hurtful to the eyes.

Another source of eye strain is produced by constant reading in railway carriages. I have often been impressed by the avidity of passengers seizing their morning paper and devouring column after column to and from their places of destination. On account of the oscillating movements of the car the paper is held inside the proper reading distance; this is done to get a larger image of the reading matter, but

in doing so the muscles of accommodation as well as the converging muscles are kept on a severe strain.

These same men pass rapidly from station to their places of business, neither looking to the right nor left of them, but with thought intent and fixed gaze they still hold these muscles with a strong grip; all day at business the same, and a repetition of the morning's work upon the train homeward bound at night, and so for ten or twelve hours those patient eyes are forced to work, which keeps up the strain, and on account of the tension more blood is brought to the parts, which in a short time produces failing sight and chronic congestion of the eyelids and eyeballs.

We must not forget that a certain amount of recreation is not only conducive to good health, but is absolutely necessary to preserve the same. Men who are constantly employed either at reading, drawing, adding up columns of figures or near work of any kind, should take short intervals of eye rest, especially those working upon white or glazed paper, wood-engravers or etchers. Nothing gives such eyes greater relief than a green disc or square of sufficient size, suspended on a direct line of vision at or against a wall on which the eyes can rest; but best of all if that individual can look upon a green grass plot or green trees.

School-rooms, instead of having blank walls, would be a source of great comfort to the overtaxed eyes of children if they were decorated with pastoral scenes, or any picture representing long distances.

Since the above was written, I have had an interview with Mr. Paul Kavanagh, Chairman of Public School property of this city, and he tells me that this idea has in a measure been adopted in the F. M. Drexel School, Sixteenth and Moore Streets. The walls are not only decorated with maps, but also with pictures of animals inhabiting certain portions of the globe. For instance, the map of Africa showing the black race, also that it is the land of the elephant, etc.

These drawings or pictures not only make school-rooms attractive, but what is more important, give the eyes a rest, while these same pictures are another means in the development of the minds of the smaller children by object lessons.

One of the most prominent and popular professors* in the Boys' High School, who speaks with an experience of twenty-five years, tells me that he has found the old-fashioned school maps with their glazed surfaces not only injurious to vision, but on account of their highly reflective surfaces difficult to see from certain positions. This style of map should have been banished from school-rooms years ago.

Pictures in which great distances are shown are the best for sitting-rooms. The drop curtains in theatres should have scenes painted on them showing great perspective; it is a rest to the eyes after the concentrated effort made in trying to watch the facial expressions or eyes of an actor, to look upon such a picture. The success of Russell Smith's scenic paintings on drop curtains, was that he always gave great perspective to his drawings.

Several theatres in this city have drop curtains in which perspective is absent, and the result is that no relief is given the eyes after each act, and people with the least visual defect always suffer from eye strain after spending an evening in such places of amusement.

Individuals who have to earn a livelihood with the pen should write on paper tinted green, blue or yellow. French authors use green tinted paper and say that they are greatly relieved from eye strain by doing so.

It is essential to preserve good sight by such means as will not interfere with good health, and the first step in that direction is to have plenty of light and air; not the heated atmosphere of the average American business place or home. I am sure that this high temperature helps to ruin people's eyes more than we like to admit; too much light, especially if it be reflected, is particularly injurious; it produces an overstimulation to the retina.

From what I have gathered from clinical observation, I find that a lesser quantity of light is less injurious to an eye than an excessive bright light. For example, miners have less visual defect than machinists who work under electric lights.

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* Prof. E. J. Houston.

The eye is so delicately adjusted that if one were to heed its warnings very little injury would result to it, but unfortunately men and women alike seem to think that at all times and under all physical conditions can this little organ be kept at high pressure; they never think that general diseases or such as usually manifest themselves in other organs may develop special eye diseases.

After the last epidemic of "la grippe" I was particularly impressed with the large number of patients complaining of the loss of power of the converging muscles of the eye. Upon investigation, I found that while these patients were confined either to bed or home, they would read incessantly.

The result of this overtaxation was weakened eye muscles, while so long as they remained unsupported by prisms the patient suffered with pain over the eye region, headaches and other evidences of eye strain.

Individuals when suffering from any depressing disease should be guarded as to the length of time they read or perform near work, as they should be to physical exertion of any kind.

It is not my purpose to go into a discussion of the medical side of the many injuries the eye receives in an indirect way, but persons who have a predisposition to catarrhal ailments, a rheumatic or strumous diathesis, must carefully avoid all sudden changes of temperature or sudden exposure of any kind, as the eye not infrequently becomes the culminating point of disease. I have seen such people greatly frightened by the sudden appearance of flying specks before their eyes.

People prone to over-eating with little or no exercise frequently have this condition as well, which is known to the profession as "Muscæ Volitantes." They are not, as many people think, the forerunners of cataracts or blindness—in fact, so long as they remain minute specks they are harmless. One thing they point to, and that is, the eye should have rest and the body made to work; an inverse condition of affairs should be brought about to that usually existing; plenty of outdoor exercise and very little near work upon white paper.

The state of the mind has much to do with vision. Violent affections or great passion, long continued grief and care, cause a diminution of the eyesight. It is recorded that extreme terror has induced blindness; violent anger or rage lessens the acuity of vision to a marked degree. All this acts like so many corroding cares perpetually undermining the stock of good sight Nature has given us.

The Archbishop of Seville, who died at the age of 110, when asked the secret of his longevity and good eyesight, said, "By being old when I was young, I find myself young now I am old."

There is one form of visual defect to which I have called attention in my former lectures before this Institute, and that is color-blindness.

In this discourse I shall allude to it not as a congenital defect, but as an acquired condition brought about by abuses.

The early history of cases of color-blindness have been imperfectly recorded; one goes back to 1684, and her case is recorded by Dr. Dawbeny as one whose vision was excellent but unable to appreciate any other color than white or black, although she could often read for nearly a quarter of an hour in the greatest darkness. Another case which is recorded more in detail is described by Robert Boyle, who writes, on p. 599, vol. 3, whose philosophical works were published in 1725, as follows:

"Two things were particularly odd in this case (he speaks of a gentlewoman twenty years of age). First, she is often troubled with flashes of lightning that seem to issue out like flames about the external angle of her eye, and often make her start, put her into frights and give her melancholy thoughts.

"Secondly, what is more strange and singular, she can distinguish some colors as black and white, but not others, especially red and green. And when I produced her a bag of fine glossy red, with tufts of sky-colored silk (blue) she looked attentively upon it, but told me that, to her, it did not seem red, but of a dark or dirty color, and the (blue) tufts of silk, she said, seemed to be of a light color, which

she compared to the silken stuff of the petticoat worn by the lady who brought her to me, and, indeed, the blues were very much alike.

"She further said, that the meadows did not appear green, but of an odd darkish color, and that when she had a mind to gather violets, though she kneeled in the place where they grew, she could not distinguish them by the color, from the grass about them, but only by their shape or touch. And the lady who was with her took thence occasion to tell me, that when she looks upon a Turkey carpet, she cannot distinguish the colors, unless of those parts which were white or black."

Medical records show that this subject remained undisturbed until Dalton described his own case in 1794, and he appears to have been in ignorance of Boyle's writings. After this period, it was called "Daltonism," and even to this day it is sometimes known by this same name.

In 1846, Prof. Wartmann's elaborate paper was translated and published in *Taylor's Scientific Memoirs*, but it was left to Dr. George Wilson, of Edinburgh, who, in 1853, contributed elaborate articles to the *Edinburgh Monthly Journal of Medical Sciences*, and in 1855 published the best book written in English on the subject. Since Wilson's day, many articles have appeared on this subject; among our own countrymen, Dr. B. Joy Jeffries, of Boston, takes the lead.

A continuation of the knowledge of colors is very important, when we know that engine drivers or men on ocean steamers have daily to peril human life, "on the indication of a colored flag or light."

Congenital color-blindness is easily detected, and color-blinds rarely apply for important positions in which color plays a *rôle* in the occupation. It is after men have secured a position and are consumers of tobacco or have passed through a severe illness, that they should again be made to undergo examinations, for tobacco, quinine and santonine enter largely into the class of drugs which might produce such a defect.

Prof. John Speiller recently read a paper on the effect of

santonine produced upon his color sense, which from a scientific point of view is interesting. I would, therefore, repeat, that all men such as engine drivers and seamen, should undergo an examination for color-blindness at least twice a year.

Dickens says somewhere that "nothing is sure in this world but death and the tax collector." I may add, that when the majority of people reach their forty-fifth year, they are sure of falling into the hands of the oculist and the optician.

One of the first concomitants of age, is acquired farsightedness or presbyopia. This necessitates wearing certain glasses for near work.

Whenever a man or woman about forty-five years of age finds himself or herself reading or threading a needle at arm's-length, their action tells that the little muscle governing the accommodation, is growing weak and needs assistance. By persisting in forcing this muscle to work, much injury is done to the eyes, but by having it corrected, many a frown would be saved to man and many a wrinkle to woman.

Not only is it important to get glasses, but of more importance still is it to see that you get the kind suitable for each eye. It is comparatively rare to find two eyes exactly alike, and the aid of an ophthalmic surgeon who is not only competent theoretically but practically should be sought.

Our city is noted for its skilled opticians, but it is also to the discredit of many of these same opticians that they will sell glasses to anyone who chooses to buy them. I do not for a moment entertain the thought that trained opticians cannot give glasses which will answer a given purpose; nay, I am sure that they can correct the simpler forms of presbyopia as well as any ophthalmic surgeon and optician.

Men whose knowledge is acquired by long experience are often much more useful than those having a theoretical knowledge only. When the optician finds, however, that the vision is not the same in each eye, or where astigmatism exists and the patient complains of symptoms now recognized

as eye symptoms, then his province ends and the ophthalmic surgeon's work begins.

At one time the druggist could exercise the prerogatives of the physician; is it of lesser import that the optician should assume the prerogatives of an ophthalmic surgeon? If the law now prevents the one from prescribing drugs, the other should also be prevented from prescribing glasses, outside of a certain range of years, or certain physiological conditions.

As age increases, excessive reading, writing or work upon very small objects must not be persisted in, especially if the eyes grow tired. It must be remembered that the elasticity of the eyeball is lost and any persistent effort may produce hemorrhage in the retina, or such a strain as may lead to other serious troubles.

Old people should be careful not to read with a strong artificial light falling on a white glazed surface. It would be better for such people if our monthly magazines were printed on paper of a neutral tint.

I now come to speak of cataracts, the most common form of eye disease in elderly people; and being so common, it is astonishing in these enlightened days that the majority of people still believe the cataract to be a skin growing over the eyes.

In Vigon's *Chirurgerie*, published in 1571, I quote as interesting reading his description of a cataract: "Oftentymes, there descend from the head certayne grosse and flegmatyke humors covering the apple of the eye and there remaining, and engrossed and made thyck, which is named of the doctors, Cataract."

It was not until about 1700 or a few years later that the real seat of cataract was understood; until this time it was supposed by the medical men and oculists to be a growth or a skin as described above, and like so many sayings, was handed down from one generation to another and has lived to this day.

The removal of cataract can only be performed by an operation. The history of operations for the removal of cataracts date from the remotest antiquity. It was known

in Egypt under the reign of Ptolomy-Soter; traces of it are found in the "most ancient traditions of Hindustan and the Chinese empire." Galen states that in his time there were oculists at Rome and Alexandria who exclusively practised this operation. In ancient and comparatively recent times the operation was performed by thrusting a needle into the eyeball a short distance behind the cornea, and turning the opaque lens downward or dislocating it completely; this removal of the cataract aided by a convex lens then gave the patient vision.

The operation followed by ophthalmic surgeons to-day is entirely different; an incision is made through the cornea with a delicate knife, and the cataract or opaque lens removed through this opening.

Many individuals with cataracts dread its removal, but with the aid of that powerful drug cocaine (which I do not believe the ancients knew anything about, and is possibly one of the few new things under the sun), and a skilled hand, successful restoration to vision is almost always anticipated.

Of all the special organs of sense the eye stands prominent among them all, like a barometer to indicate the physical condition within the body.

When patients are brought to us with red or inflamed eyelids and a history of a succession of sties, do we simply give eye salves? No! First, we seek for causes more remote and find them in defective vision.

When ulcers of the cornea exist, it shows that the blood must be impoverished and food is not assimilated.

When that white band around the outer edge of the cornea called the "Arcus Senilus" is visible, what does that indicate? Your physician will tell you that fatty degeneration of muscular tissues is taking place, and nothing must be done to produce over-action of the heart.

When the eyelids are puffy and seem to be filled with fluids, it tells the observing physician facts more potent than words.

The pupils of the eyes speak for changes going on in the brain or upper portion of the spinal cord, and when we examine the interior of the eye with the ophthalmoscope,

what a new world is unfolded to the observing and keen ophthalmic surgeon! We are thus able to tell whether a patient is suffering from tumor of the brain or meningitis, Bright's disease or diabetes.

In this lecture I have tried to call attention to many evils which not only directly injure health, but the vision as well. It is a melancholy circumstance that so many young persons will deliberately try to undermine their good health, so that when they reach the age of fifty in years, they are at least seventy in aches and pains.

> "Hard toil can roughen form and face,
> And want can quench the eyes' bright grace.
> Nor does old age a wrinkle trace
> More deeply than despair."
>
> —*Marmion.*

In conclusion, I venture to give you a few more hints on the care of your eyesight:

(1) Avoid sudden changes from dark to brilliant light.

(2) Avoid the use of stimulants and drugs which affect the nervous system.

(3) Avoid reading when lying down or when mentally and physically exhausted.

(4) When the eyes feel tired, rest them by looking at objects at a long distance.

(5) Pay special attention to the hygiene of the body, for that which tends to promote the general health acts beneficially upon the eye.

(6) Up to forty years of age bathe the eyes twice daily with cold water.

(7) Do not depend on your own judgment in selecting spectacles.

(8) Old persons should avoid reading much by artificial light, be guarded as to diet and avoid sitting up late at night.

(9) After fifty, bathe the eyes morning and evening with water so hot that you wonder how you stand it; follow this with cold water, that will make them glow with warmth.

(10) Do not give up in despair when you are informed that a cataract is developing; remember that in these days of advanced surgery it can be removed with little or no danger to vision.

PROCEEDINGS
OF THE
CHEMICAL SECTION
OF THE
FRANKLIN INSTITUTE.

[*Stated meeting, held Tuesday, May 17, 1892.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 17, 1892.

Dr. Wm. H. Wahl, President, in the chair.

A paper on "An Improved Method of Determining Small Percentages of Gold and Silver in Base Metal," by Mr. Cabell Whitehead, of Washington, D. C., was read by Dr. D. K. Tuttle. It was followed by an interesting discussion.

The paper was referred for publication in the *Journal*.

Mr. F. Lynwood Garrison then gave a number of views of the recently conducted armor-plate tests at Indian Head proving ground. Mr. Garrison discussed the results of these tests from the metallurgical standpoint. The complete report of Mr. Garrison to the Institute will appear in the *Journal*.

Adjourned. WM. C. DAY, *Secretary*.

AN IMPROVED METHOD OF DETERMINING SMALL PERCENTAGES OF SILVER AND GOLD IN BASE METALS, MATTES, ETC.

BY CABELL WHITEHEAD,
Assayer to the Mint Bureau, Washington, D. C.

[*Read at the stated meeting held May 17, 1892.*]

Any one having frequent occasion to report the values of silver and gold in such material as crude copper, copper mattes or ores, metallic iron, zinc, etc., will appreciate the advantages of a method which affords accurate results with little expenditure of time. The large production of pure copper by electrolytic methods from silver- and gold-bearing copper ores, renders some such method very desirable in

view of the various transfers of, (1), ores to the smelters; (2), mattes to the refiners; and last, the crude copper to the electrolytic refinery, each of which transfers carries a commercial charge of the bullion contents.

While the proposed method is available for a great variety of base products, it will perhaps best be illustrated by its use in determining the silver and gold contents in crude copper or the mattes resulting from bullion-bearing copper ores. The adaptability of the method to other base metals will readily suggest itself to the experienced assayer.

Given a crude copper or matte carrying from thirty ounces of silver and ·10 of an ounce of gold, upward, the usual method would be scorification. It is usual to take for assay from ·05 to ·1 assay ton to each scorifier, with which are used from forty to fifty grammes of test lead, one-half of which is mixed with the ore in the scorifier and the remainder used as a cover. The scorifier is now introduced into a hot muffle and the door closed until the lead is melted, when it is opened and about one gramme of borax glass placed on the lead. Oxidation begins at once and the lead and base metals are rapidly scorified off until the slag covers the metal, when the assay is poured into a mould. If the lead button still retains much copper, or is hard or brittle, it is again scorified, with the addition of more test lead if necessary. When the lead button is soft and of proper size, it is cupelled and the button weighed and parted. Several scorifications are sometimes necessary before the button is ready for the cupel.

The two objections to this method are, first, the loss of silver during scorification and cupellation, the latter due chiefly to the copper remaining in the lead which it is practically impossible to remove in the scorifier, and which takes silver into the cupel. These losses I found to amount to from 2·33 to 2·78 per cent. of the silver present in the copper. My experiments were made with pure copper and pure silver, the silver being added in the proportion of 100 ounces per ton of alloy.

The second objection is the small amount of bullion which can be operated upon, which necessitates the use of

many scorifiers where small amounts of gold are to be estimated, which is usually the case.

To avoid the doubtful results of scorification processes, the following method has been adopted at the copper works of a firm having large interests at stake:

One assay ton of copper is dissolved in nitric acid, diluted and allowed twenty-four hours to settle. The solution is now filtered from the slight sediment containing the gold. A few drops of hydrochloric acid are added to the filtrate and the solution again allowed twenty-four hours for silver chloride to deposit, when it is filtered, washed and the two filters dried, combined, scorified with test lead and cupelled. The chief objections to this are, (1) the time required; (2) the small amount of precipitate obtained and the danger of loss in scorifying silver chloride; (3) the greater solubility of silver chloride as compared with the bromide.

While the method used at these works is an advance over previous practice, yet the time employed and the uncertainties indicated, leave much to be desired. The protracted time allowed for settling is necessitated by the exceedingly fine condition of the gold resulting from the solution of a metal carrying possibly from ·10 to 5 ounces of gold per ton of metal. It would pass through a filter unless allowed to aggregate by standing.

The larger quantity (say 100 ounces) of silver per ton will give but a slowly subsiding cloud (impossible to filter) when newly precipitated as chloride. The scorification of these combined precipitates, one of them being silver chloride, cannot give results quite satisfactory, despite the time involved, some forty-eight hours at least.

The method which I will now briefly describe was devised to meet just such cases, and is suitable for the bullion valuation of zinc, iron, nickel, etc., as well as the sulphides and arsenides of iron and copper. To illustrate the proposed method, which has been found effective and useful, the treatment is detailed for a crude metallic copper carrying both silver and gold. It will be understood that sodium bromide is chosen as a precipitant because of the greater insolubility of silver bromide over the chloride, and also

that the soluble lead salt is added in order that the heavy precipitate of lead bromide may envelop and promptly carry down the silver bromide cloud. which otherwise would require long waiting for its subsidence, as well as to furnish the lead necessary for cupellation.

Weigh out from one to four a. t., depending upon its richness, place it in a beaker of 500 cc. capacity and add gradually enough nitric acid to dissolve it completely, heat until red fumes cease to come off, dilute with water and add fifty grammes of lead acetate, stir, and when dissolved, add one cc. dilute sulphuric acid and allow the lead sulphate to settle. Filter into a 1,000 cc. flask and fill to the mark with distilled water.

The filter contains the gold which has been collected and carried down by the sulphate of lead. The filter paper and precipitate are dried, the paper burned and the ash and lead sulphate scorified with test lead. The button is cupelled and the gold, with any trace of silver it may contain, is weighed. Add silver and part the gold in the usual way. Note the amount, if any, of silver found and include the proper proportion of the amount with that found in the solutions as about to be described.

In order that there may be a control assay, the solution is divided into two equal parts, to each of which a saturated solution of sodium bromide is added with constant stirring as long as a precipitate is produced. The precipitates settle quickly and filter and wash well. Cold water only should be used, and the washing be continued until the washings are free from copper. Any bromide of lead dissolved during the washing, may be neglected, as I have never found it to contain more than a trace of silver, even when assaying ores carrying many thousand ounces.

The precipitate when dry can be brushed from the paper without difficulty, and thus the trouble of burning the filter is avoided. The bromides are now mixed with three times their weight of carbonate of soda and a small amount of flour or other reducing agent, placed in a small crucible, covered with borax glass and melted down in the muffle. The button should weigh about two grammes and be free

from copper and other injurious impurities. This button is cupelled at a low temperature, so that the cupel "feathers" nicely. The time required is from three to five minutes. Duplicate assays usually agree within two-tenths of an ounce per ton.

The following examples are from copper bullion:

		Oz.	Oz.	Oz.
No. 1,	silver	61·30	61·20	gold ·10
No. 2,	"	63·45	63·30	" ·17

Had the gold button contained silver, one-half of its silver contents would have been added to the silver recovered from the solutions, since the gold is estimated on the whole weight, while two determinations of silver are made on the same weight.

The following is an example from a silver-bearing cast iron from the U. S. Mint at Philadelphia. It was dissolved in nitric acid, diluted and precipitated with lead and sodium bromide. After washing, the bromides were dried and brushed from the filter. No. 1 was mixed with ten grammes of litharge, a little flour, the usual amount of soda and covered with borax. Melted down and cupelled, the button gave 30·80 ounces per ton. No. 2 was mixed with test lead and borax and scorified. It gave 29·90 ounces per ton, ·90 of an ounce less than No. 1. However, this would be considered a very close agreement by the old method.

The following is an ore from Colorado, very base and with a gangue of sulphate of barium. It proved very unsatisfactory to assay by scorification, duplicates not agreeing at all. The ore was treated with nitric acid and filtered, the residue being assayed separately.

The following are my results:

	No. 1. Oz.	No. 2. Oz.
Residues,	32·50	35·95
Solutions,	454·90	453·30
As a total,	487·40	489·25
Difference of	1·80	

Gold was not separated in the residues. The highest assay gotten by scorification was about 467 ounces, which shows twenty ounces in favor of the new method, with a reasonably close agreement in different assays.

PROCEEDINGS
OF THE
ELECTRICAL SECTION
OF THE
FRANKLIN INSTITUTE.

[*Stated meeting held Tuesday, May 3, 1892.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 3, 1892.

Prof. Edwin J. Houston, President, in the chair.

Present, thirty members and visitors.

The minutes of the previous meeting were read and approved.

The Treasurer reported the cash balance in the treasury, and presented bills for printing, which were approved and ordered paid.

One nomination to membership was referred to the Committee on Admissions.

The proposed amendment to the by-laws substituting the word *fourth* for *first*, in Article II, Section 1, so that it reads: "The stated meetings of the Section shall be held on the fourth Tuesday of each month, at 8 P.M., except during the months of July and August," was voted upon and adopted.

This by-law was then temporarily suspended upon motion that the next regular meeting shall be held Tuesday, May 31, 1892.

Mr. Paul A. M. Winand read a paper on "Some Points Regarding Multiphase Current," illustrated by black-board sketches and ingenious working models. To be continued at next meeting, and referred for publication. In discussion thereon, Mr. Carl Hering stated that he thought the term *multiphase* usually applied to currents of two or three phases, and *polyphase* to those of more than three. He and Mr. Wm. S. Aldrich described other diagrammatic methods of representing the variations in alternating currents.

Mr. Carl Hering read a paper on "Ampère-Centimetre: A Measure of Electro-magnetism." It elicited considerable discussion, and was referred for publication.

The meeting then adjourned.

L. F. RONDINELLA, *Secretary.*

CONSTANT SHUNT METHOD FOR THE MEASUREMENT OF LARGE CONTINUOUS CURRENTS.

By Clayton W. Pike.

[*Read at the stated meeting of the Section, held March 1, 1892.*]

The constant, Vienna or Munich, shunt method, as it is variously termed, is something which is by no means novel and is, indeed, well known to some of the section, having been used by them at the Electric Exhibition of the Institute, in 1884. But I believe that the method is not so well known, or at least not so much in use as it should be, and I hope, by calling attention to some of its advantages and by pointing out and showing how to avoid certain errors incident to it, one or two of which are not generally known, to do something toward bringing it into more general use.

For the measurement of continuous currents we have the various forms of ammeter, the Siemens dynamometer, the Thomson platform galvanometers, and the Thomson balances, the tangent sine and cosine galvanometers. With the objections to the ammeters all are doubtless familiar. They are inaccuracy of graduated scale, errors due to residual magnetism or to loss of permanent magnetism, and lack of wide range. The Thomson platform galvanometer does not measure large currents without the use of the permanent magnet which is objectionable if considerable accuracy is desired, and it requires a knowledge of the horizontal component of the earth's magnetism H. The Thomson balance is an instrument of much greater value than the above, being independent of H, having greater range and greater precision, but being even more costly.

The tangent galvanometer requires the value of H, and has only a limited range, which the sine and cosine, though better in this last respect, are tedious to use on account of time required in setting the coils.

The great advantage of the shunt method over all these is that, by the aid of fairly simple and cheap apparatus, currents varying from one to 1,000 ampères or more may

be measured with quickness and a very great degree of accuracy over the whole range.

The shunt method is really a comparison method, and depends upon Ohm's law that the potential difference between two ends of a resistance is proportional to the current flowing through the resistance.

Let $A\ B$ be a conductor whose temperature is kept constant, its resistance will therefore be constant, but need not be known. Pass the current C, which we desire to measure through $A\ B$, there will then be a potential difference $P\ D$ between A and B.

Let G be a mirror galvanometer with telescope and scale, then the deflection d is proportional to the current through it, which is proportional to $P\ D$, as long as resistance of galvanometer and leads is constant, $d_1 \propto P\ D_1$ or $d_1 \propto C_1$.

Pass any other current C_2 through $A\ B$ then $d_2 \propto C_2$ and

$$C_1 = \frac{d_1 C_2}{d_2}$$

If the resistance of the galvanometer and leads be not constant, the algebraical result is less simple and, moreover if the deflections become very large, they are not strictly proportional to the current through the galvanometer which we will call C_g. Hence the comparison of large with small currents will be somewhat inaccurate. This leads us to a little different method. Place a resistance box R in the galvanometer circuit. Pass current C_1 through $A\ B$, causing a potential difference $P\ D_1$, and sending through G a current

$$C_1 g = \frac{P D_1}{R_1 + g}$$

where g is the galvanometer resistance.

Then

$$d_1 \propto C_1 g \propto \frac{P D_1}{R_1 + g}$$

or

$$C_1 \propto d_1 (R_1 + g)$$

in the same way

$$C_2 \propto d_2 (R_2 + g)$$

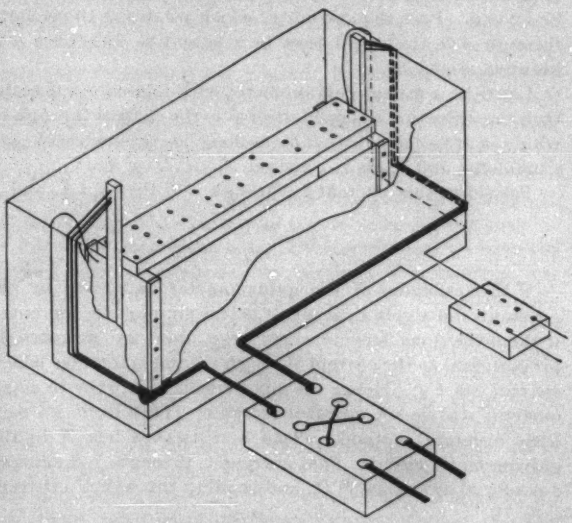
then

$$\frac{C_1}{C_2} = \frac{d_1(R_1+g)}{d_2(R_2+g)}$$

or

$$C_1 = \frac{d_1(R_1+g)}{d_2(R_2+g)} C_2$$

Now, if when C_2 were flowing we had accurately measured



it by a tangent galvanometer or by the electrolytic cell, the quantity

$$\frac{C_2}{d_2(R_2+g)}$$

would be known. Call it K the constant of the shunt. Then we have the general formula for the shunt that the current whose value we desire is equal to

$$d(R_1+g)K$$

Now, by using the resistance box, and by adjusting it to

give about the same deflections on the galvanometer in different measurements we have secured two important advantages.

(1) We have done away with the error of assuming that the currents through the galvanometer was strictly proportional to its deflections.

(2) The resistances R being large in value with reference to galvanometer and leads, and being of platinoid or some metal with very low temperature coëfficient, any change in temperature of galvanometer and leads will produce little effect on the result.

Like all other methods this one is liable to certain errors, some of which I will mention and briefly suggest their remedies. The way in which they affect the result will also be stated.

(1) *Reading of Deflection.*—Suppose you could read to within ·01 cm. on the scale. If the deflection were 10 cm. the error would be

$$\frac{\cdot 01}{10} = 1 \text{ part in } 1{,}000.$$

The error is evidently diminished as we increase the deflection.

(2) *Error Due to Temperature Change of Galvanometer and Leads.*—If these are of copper their resistance would change four-tenths per cent. per degree Centigrade. This correction could be applied, but if the resistance in R is large with respect to g, this correction will be negligible; (2°) then conflicts with (1°), and we must compromise. Suppose $R_1 = 20\ g = 2$, and temperature rise = 10° C. then the true value of

$$R_1 + g = 20 + 2 + 2 \times \frac{4}{100} \times 10 = 22{\cdot}08$$

and the error in neglecting the

$$\cdot 08 = \frac{\cdot 08}{22} = 1 \text{ in } 275$$

(3) *Error Due to Temperature Change of Box.*—This is ·02 per cent. per degree Centigrade for platinoid coils, and may be

corrected for, or neglected, according to the desired precision of our results.

(4) *Error Due to Determining Constant K.*—The constant is best determined in most cases by electrolytic cells, say three in series. If one has a tangent galvanometer of proper range, 1-5 ampères, and knows *H* to the desired accuracy this may be used. A Thomson deci-ampère balance would be very convenient for subsequent determinations of the constant, if its readings were known to be correct within the desired degree of accuracy. An error of ·1 per cent in *K* causes an equal error in the subsequent measurements.

(5) *Error Due to a Rise in Temperature of the Shunt.*—This may be due to two causes: a rise in the temperature of the room, or the heating effect of the current. Both may be obviated by placing the shunt in liquid artificially cooled

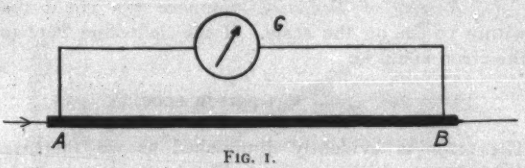


FIG. 1.

by cold water coils, and keeping constant the reading of a thermometer placed in the liquid close to the shunt.

Suppose the rise in temperature were 5° C. If the shunt were of German silver the change in its resistance would be ·04 per cent. × 5 = ·2 per cent. or two parts in 1,000, and the results of the measurement would be in error by this amount. If of platinoid, the error would be but half as much.

(6) *Error Due to Change of Value of H.*—This would be possible if the galvanometer had the earth's field for a resting force. If great accuracy be desired, obtain the value of the constant frequently, and see if it changes. As I have before said a Thomson balance would be most desirable for this, and many laboratories can afford one Thomson balance. Also if we had a galvanometer whose damping could be removed, we could determine whether *H* had changed by its time of vibration. The sources of

error so far mentioned are well understood and looked out for, but the following are, I believe, not so well known. At least the amount of the effect is not so generally appreciated, and they have, so far as I know, received exhaustive study only at the hands of Mr. W. L. Puffer, of the Massachusetts Institute of Technology. His results are to be found in the *Proceedings of the American Academy of Arts and Sciences*, January, 1888.

(7) *Error Due to Thermo-electric Effects.*—We are obliged to make the resistance of our shunt very low to prevent undue heating, hence the potential differences set up at its terminals are very low. In this case any thermal E. M. F.'s, which might be caused by differences of temperature at the junctions of the different metals, would be liable to affect the readings of the galvanometer. This trouble may be obviated by so making the shunt as to put the junctions under the surface of liquid whose temperature is maintained constant and may be detected by running the galvanometer leads to a mercury cup commutator and testing with reversals.

(8) *Error Due to Electro-chemical Action.*—The shunt is placed in liquid and under the action of the potential differences set up at its terminals there is electrolytic decomposition, (if the liquid be one which can be decomposed as water). This will cause the end having the higher potential to be darkened, owing to oxidization of the German silver by the oxygen set free, while the other end will become whiter or cleaner in appearance, owing to the reduction of the film of oxide on its surface by electrolytic hydrogen. These actions will evidently set up E. M. F.'s, and if the shunt resistance is very low, will cause considerable error in the result. This source of error could be avoided by placing the shunt in some liquid incapable of decomposition with low E. M. F.'s. Chemically pure water would do, but for the trouble of obtaining and keeping it so. Petroleum oils would act slightly on the bare piece of metal composing the shunt, thus producing a battery effect. We must either immerse the bar in some liquid incapable of acting on it or cover the shunt very carefully with some substance not acted upon

by the liquid in which it is placed. Everything considered it seems to me that very carefully covering the shunt with several coats of shellac and afterwards with copal varnish, and immersing it in distilled water would be the most satisfactory method.

Design and Construction of Apparatus.—Suppose we desire to measure currents of from one to 1,000 ampères. This would require a set of five tangent galvanometers of different sizes, the three largest of which would be impracticable. (The diameter of the largest would be about seventy-five feet.) With the sine or cosine galvanometers or Siemens dynamometer we could do better in this respect, but they are still out of the question.

With the Thomson platform or balance we should need three different instruments, which are exceedingly costly.

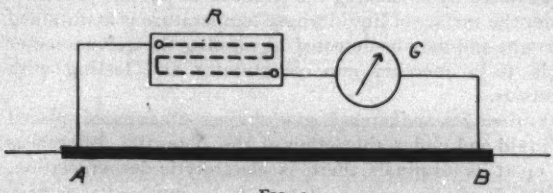


FIG. 2.

Moreover, none of these could be used near dynamos and this means that we must lead the whole of the current we wish to measure perhaps a considerable distance, thus entailing expense for wire and perhaps leakage.

Suppose we make one shunt of resistance ·001 ω. If of German silver 9 inches wide, $\frac{1}{100}$ inch thick, two strips 24 inches long joined in parallel will be nearly the required dimensions. The object of making them so thin is to offer large surface to the water so that they may quickly dissipate the heat produced by the current. The rate of production of heat with the maximum current 1,000, ampères, will be $\cdot 24\ C_2 R = \cdot 24 \times 1{,}000^2 \times \cdot 001 = 240$ calories or enough per second to heat 240 grammes of water 1° C. if none of the heat be dissipated. We must now provide a containing vessel large enough to hold so much water that it will not be

unduly raised in temperature, and large enough to admit of placing in it coils of pipe which shall carry cooling water if this be found necessary with the larger currents.

The two German-silver strips should be joined thus by massive cast copper blocks, to which they are carefully soldered. To make the junction doubly secure, thin strips of copper 9 x 1 x $\frac{1}{4}$ inch are screwed and soldered on over the German silver, as shown. The vertical projecting copper bars *D* and *F* are for connecting the shunt into the circuit where we wish to measure the current.

The arrangement so far described would collapse, owing to the thinness of the German silver. So it is necessary to hold the copper blocks apart at the top and bottom by some arrangement which shall be insulated from the shunt. This can be done by screwing on to both top and bottom of the copper blocks, a piece of board 24 x 4 x 1 inch, as shown in drawing. The board on top should be pierced with a large number of holes, as shown, in order to facilitate the circulation of water. The ends of the boards touching the blocks should be soaked thoroughly in melted paraffin and coated with shellac. The screw holes in the blocks should be filled with paraffin, the screw heads countersunk in the wood, as shown, and melted paraffin poured over them. The whole arrangement should then be coated with shellac and copal varnish *thoroughly*.

The containing vessel may be of wood, paper or galvanized iron, about 32 x 14 x 13 inches. Such a vessel will contain, besides the shunt, about 85,000 grammes of water. Now, the number of heat units, small calories, developed in one second by 1,000 ampères flowing through ·001 ω is in one second as before stated, such as would heat 240 grammes of water 1° C. Hence it would take to heat 85,000 grammes 1°, a time $\frac{85000}{240}$ seconds, or about six minutes, if there were no radiation. But it is probable that this heat produced will not be instantly communicated to the entire mass of water, hence, for the large current measurements it will be advisable to lead coils carrying cold water close to the German-silver strips, both inside and outside, if we desire great accuracy in our measurements.

Galvanometer.—Any form of sensitive reflecting galvanometer which is dead heat and wound with coils of low resistance may be used. If the instrument has the earth's field alone for a restoring force, as is generally the case, (neglecting torsion), it would be convenient to have the

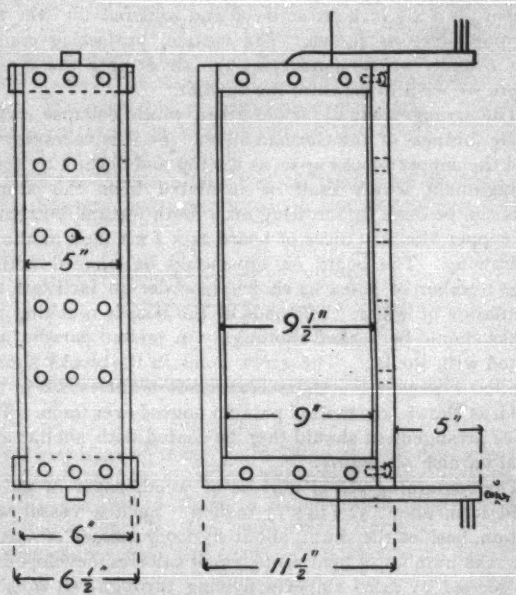


FIG. 3.

damping copper mass easily removable. The following will illustrate the design:

Suppose the scale of telescope is divided into millimetres, and we can read with an error of ·1 mm. by eye estimation, then with a deflection 10 cm. the error in reading would be $\frac{1}{1000} = 1$ in 1,000. If our scale were distant from mirror of telescope by 1·5 metres, the deflection of the mirror for a reading 10 cm. would be about 2° for $\frac{10}{150} = tan.\ 2\ a = 2\ tan.$

α approximately. $tan.\ \alpha = \frac{10}{300} = .033$ and α the deflection of mirror $= 1° 54'$.

When 1,000 ampères are flowing, the potential difference acting to send a current through the galvanometer is $100 \times .001$ or one volt. Suppose we put in the galvanometer circuit 10,000 ohms, the maximum of an ordinary box, then the current through the galvanometer will be .0001 ampères. With sufficient accuracy, we may apply the tangent galvanometer formula,

$$C = \frac{10\ H\ \gamma\ tan.\ \alpha}{2\ \pi\ n}$$

from which we have

$$n = \frac{10 H\ \gamma\ tan.\ \alpha}{2\ \pi\ C} = \frac{10 \times .2 \times \gamma \times .033}{2 \times 3.1416 \times .0001}$$

Assume a mean radius $\gamma = 2.5$ cm., then n the number of turns $= 266 = 41.78$ metres or about 136 feet of wire. If we take a copper wire whose diameter bare is .036 inches the resistance will be about 1.1 α, and the wire will lie in a groove $1 \times \frac{1}{8}$ inch, whose mean radius is 2.5 cm., or about one inch.

When one ampère goes through the shunt the potential difference will be $1 \times .001 = 1$ volt. Then to give about 10 cm. deflection we should insert such a resistance that the galvanometer current would be .0001, and this resistance would be about nine ohms. Then should the temperature of the galvanometer coil rise 5° C., the resulting error would be but two parts in 1,000 from this cause alone.

A galvanometer of the D'Arsonval pattern might be used and would have the advantage of being independent of any changes in H, and of being very dead heat. It should be designed with as low resistance as is consistent with the condition that a current .0001 ampères shall produce a deflection of 2°.

Two commutators are necessary. The larger receives the six coarse wire soldered into the copper lugs $D\ F$ of the shunt, shown in *Fig. 3*. These wires should be No. 0000 B. and S. three in parallel, and the commutator of the mercury cup

variety, so arranged that the shunt can be entirely disconnected from the dynamo circuit.

Into each of the holes at *H* and *K*, *Fig. 3*, should be soldered, carefully, a No. 18 B. and S. copper wire thoroughly insulated, and the joint covered carefully with shellac and copal. These are led out to the small mercury commutator for the galvanometer circuit arranged like the other so that the galvanometer can be isolated from shunt and main circuit. Then any thermo electric or electro chemical effects can be detected and studied. For instance, disconnect galvanometer entirely from commutator and note reading. Connect it to commutator with shunt unconnected, and there should be, of course, no deflection even by reversing the commutator. Connect shunt (still with no current in it) to galvanometer commutator, and see if there is any deflection, reversing this time the connection from shunt to galvanometer. Finally, run current through shunt, and see whether changing the commutators produces any change in deflection, being sure that this current is maintained constant. Disconnect shunt from dynamo circuit, and see whether there is any appreciable deflection. The time occupied for these tests is very short, if the commutators are properly arranged, and if the tests show no appreciable thermo-electric or chemical effects, we may feel

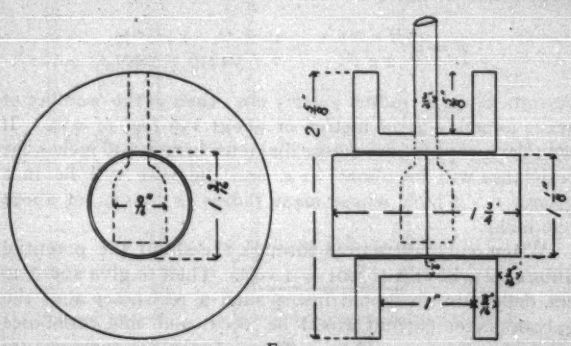


FIG. 4.

sure that our apparatus is satisfactory in this respect. Finally, provide a sensitive thermometer whose range is from about 60° F. to 80° F., or 15° C. to 27° C., and arrange so that it will be placed close to one of the German-silver strips of the shunt. Read when no current is flowing, and then when the maximum current flows. Then if these readings differ 5° C., or 9° F., the error would be two per cent., as previously stated. If greater accuracy be required send cold water through the coils, and read the thermometer, then by sending the water through fast enough, the heating effect of the current may be nullified to the desired extent.

The sketch below shows the general appearance of the completed shunt, together with the commutators.

Recent researches of Prof. Ayrton on the D'Arsonval galvanometer indicate that such a type wound with plati-

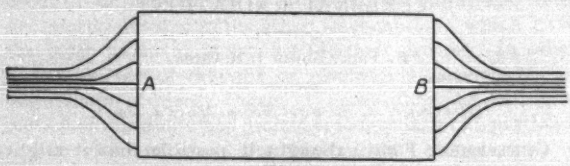


FIG. 5.

noid with phosphor-bronze strip suspensions would be most desirable, and, therefore, the following arrangement commends itself, more especially where the field around the galvanometer is subject to fluctuations. Use for the shunt bar a sheet of platinoid, to which the wires carrying the main current should be soldered. Preferably there should be several such wires soldered on the end edge of the sheet and distributed at equal distances along the edge so as to secure uniform distribution of current in the strip. *Inside* at the points *A* and *B* the leads (of platinoid) to the galvanometer commutator should be fastened. If then a D'Arsonval, made as above and having its telescope and scale rigidly attached to itself, be provided, it may be used where the other arrangement would be out of the question, namely, near the dynamo room. Moreover, by making everything of platinoid, we have done away with temperature correc-

tions, provided the platinum strip be of such dimensions that the maximum current doesn't heat it appreciably. The strip then may be kept in air, the only danger being a greater liability to thermo-electric effects due to differences in temperature at the junctions, and this can be tested by commutation.

Using the D'Arsonval, we can get a greater deflection for a given potential difference at its terminals, therefore, the resistance of the strip may be made lower and less energy be used up in the method of measurement, and in some cases this is an important advantage. On the other hand, since we measure with smaller potential differences, any thermo-electric effects will produce a greater error in our results.

CEREBRAL RADIATION.

By Prof. Edwin J. Houston.

[*Read before the Electrical Section, March 1, 1892.*]

Gentlemen: I have thought it possible that it might interest you to consider some rather wild speculations in which I have indulged for a number of years past, but which I have heretofore refrained from publishing. In these speculations, to which I was first led by a suggestion from a friend, I have endeavored to correlate, to some extent, the phenomena of thought with grosser physical phenomena. Although the suggestions I have to offer as a basis for a hypothesis of the mechanism of cerebration, are confessedly incomplete, and, perhaps improbable, yet I have concluded to place them on record as of possible interest to the scientific world.

I am, of course, aware of the fact that the psychical operations of the brain are by no means understood. It is generally believed, however, that the seat of psychical activity is the cerebrum. The manner in which the brain acts to produce, record, and reproduce thought is unknown, and will probably remain unknown.

On the single assumption, however, that cerebration or thought, whatever may be its exact mechanism, is accompanied by molecular or atomic vibrations of the gray or other matter of that part of the brain called the cerebrum, I would propose the following hypothesis to account for telepathy, mesmerism, thought transference, hypnotism and other cognate phenomena.

Postulating the existence of the universal or luminiferous ether, which is now generally accepted in scientific circles, and bearing in mind the fact that this ether passes through even the densest matter, as easily as water through a sieve, it follows that the brain atoms or molecules that are here assumed as the cause of cerebration, are completely surrounded by the ether. Now, since the ether is a highly elastic, easily movable medium, it would follow that thought or cerebration, if attended by vibrations, must necessarily develop in the ether wave-motions, which have the brain atoms or molecules for their centres. In other words, the act of thought or cerebration necessitates an expenditure of energy, because it necessitates the setting in motion of these assumed atomic or molecular brain particles.

The exact nature of the motions that are assumed to attend an active condition of the brain must necessarily remain unknown as long as we are ignorant of the exact nature of the mechanism that is moved. But, if an active brain evolves thought because something is set in motion, it, of course, follows that a brain absolutely free from producing thought must be at rest so far as that kind of motion is concerned. An absolute freedom from thought in a healthy brain is most probably a condition that seldom exists; relative rest, however, must be quite common.

That the brain cells, of the gray or other matter involved in the production of thought, can be caused to assume certain groupings or relations towards one another would appear to follow from the ease with which that curious function of the brain called memory, permits it to readily recall past peculiarities in the to-and-fro motions. By continually repeating certain trains of thought, as in study or repeated observations, the peculiar motions required to pro-

duce such thought are probably given a set or tendency to form more or less permanent groupings. When, therefore, the brain is moved or played upon, so to speak, these motions recur and certain memories are awakened.

How may these motions be produced? The answer would certainly appear to be both from within and without. It is, perhaps, possible that the flow of blood to an active brain, which as is well known attends all active cerebration, is not only for the purpose of nourishing and rebuilding the organ, but also for affording the purely mechanical force, that needs but to touch this marvellously attuned organ to awaken the thoughts already impressed thereon, or to sit in judgment on new combinations never before presented to it.

I will suggest an explanation later on as to how these impressions may possibly be excited from without.

Whatever be the origin of these vibrations, or, however, excited, energy is required to be expended in producing them, and as the brain-worker will readily acknowledge, the expenditure of such energy often calls for an enormous expenditure of nervous force.

Cerebral energy, or energy thus expended in producing thought, is dissipated by imparting wave motions to the surrounding ether, and such waves are sent out in all directions from the brain, possibly in greater amount, or of greater amplitude from some of the brain openings, as, for example, those of the eyes.

Although there are no absolute proofs of the existence of the molecular or atomic vibrations of the brain particles which I have assumed, such a movement, however, is far from being improbable, and, indeed, some facts known to the medical profession are far from being at variance with such an assumption. A certain amount of pressure on the brain arising from the pressure of the blood is necessary for its proper action. If this pressure increases beyond a certain value, as, for example, in cases of fractures of the skull, where a portion of the bone is depressed by the fracture, thereby producing a compression on the brain material, all thought or cerebration instantly ceases; but when this

pressure is relieved, by the act of trephining, cerebration not only begins, but curiously enough, generally goes on from the point where the patient left off, when the injury occurred.

Let us assume, then, that cerebral radiations or waves are given off from every sentient or active brain, and that these waves pass into the space around the brain something like the waves that are imparted to the air around a sounding tuning-fork.

The cerebral radiations are not so gross as those of sound. Their wave-lengths are almost certainly much shorter. They are imparted to the universal ether.

If such waves, which I would call thought-waves or cerebral-waves, be present in ether that fills all space, it will be interesting to inquire what phenomena they might be expected to produce.

It being assumed that these vibrations take place in the ether itself, there need be no doubt or speculation as to the general nature of the waves themselves. They would presumably partake either of the nature of transverse or torsional vibrations.

The commonest character of the vibrations which occur in the universal ether are the vibrations which are now generally recognized as transmitting the phenomena of heat, light, electric or magnetic radiations; viz., of transverse or torsional vibrations.

An active brain may, therefore, be regarded as moulding the ether around it into thought-waves, that are spreading outwards from it in all directions. In this respect, it is not unlike a conductor through which an oscillatory discharge is passing, producing those waves which Hertz has so beautifully demonstrated as resembling the vibrations that produce light.

Assume, then, that the cerebral radiations partake of the nature of thermal, luminous, electric or magnetic radiations, and the following explanation of telepathy, or thought transference, is, to say the least, not improbable.

I would explain the possibility of the transference of specific cerebral vibrations from an active brain, to a passive

or receptive brain, by the simple action of what is known in science as sympathetic vibrations.

Take the case, for example, of a vibrating tuning-fork, that is sending off its waves across the space which separates it from a second tuning-fork, not as yet in motion, but tuned so as to be able to vibrate in exact unison with it. As is well known, the exact correspondence between the period of the active, or the transmitting-fork, and the passive- or the receptive-fork, is such that the vibrations of one fork are gradually taken up by the other fork, so that the energy of the motion of the one is transferred or carried across the space existing between them, by means of pulses or waves, set up in the air which surround them.

As is well known, such sympathetically excited vibrations can be produced in a fork situated at a considerable distance from the exciting-fork.

Or, similarly, take the case of the sympathetic vibrations excited by waves of light. Solar energy is radiated or transferred across the space existing between the sun and the earth by waves or oscillations in the luminiferous ether. These waves, falling on the delicate structure of a leaf, suffer a species of selective absorption, certain wave-lengths being absorbed and others thrown off. The absorbed waves excite or produce sympathetic vibrations in the molecules of carbon dioxide present in the leaf, and cause the atoms of carbon and oxygen in such molecules to move towards and from one another in inter-atomic vibrations, which increase in amplitude or violence until their chemical affinity or atomic attraction is overcome and dissociation occurs. The oxygen is then thrown from the leaf into the air, and the carbon is retained in the structure of the plant.

Or, take the still more interesting case of what Hertz calls electric resonance. As already mentioned, it is now generally recognized by electricians that a conductor, which is the seat of an oscillatory electric discharge, is sending into the space around it electric waves or oscillations which travel with the velocity of light, and which are in fact of exactly the same nature as light itself. If

these electric waves meet a circuit so tuned as regards the period of oscillation of the circuit in which they originally occurred, as to be in consonance with them, electric oscillations will be set up in this circuit, of exactly the same nature as those exciting it.

In view of these facts it does not seem improbable to me, that a brain engaged in intense thought should act as a centre of cerebral radiations, nor that these radiations proceeding outwards in all directions from such brain should affect other brains on which they fall, provided, of course, that such brains are tuned to vibrate in unison with them. In such cases the absorption of energy by the recipient brain may be either a species of selective absorption, in which its train of thought is only modified, or it may be absolute, in which case the recipient brain has excited in it an exact reproduction of the thoughts of the exciting brain.

Such a hypothesis is far from improbable; on the contrary, it would appear to be supported by a variety of curious circumstances, which have only wanted some general hypothesis to properly correlate them.

If such a hypothesis be true, then these cerebreal vibrations or radiations must travel through space with exactly the velocity of light. This is of course on the assumption that the vibrating or oscillating brain molecules or atoms set up vibrations similar to those of light. Of course, this equality between the velocity of cerebral wave propagation and that of light is true only for free ether. In the ether which fills the interatomic of intermolecular spaces of gross matter, or, as it is technically called, combined ether, the velocity of wave propagation varies according to the particular character of the matter with which it is associated. A retardation or decrease in the velocity of the assumed cerebral waves would doubtless be experienced while passing through the materials of the skull and head.

If thought travels along waves in the ether similar to waves of light, it would be able to travel along any path by which rays of lights cax pass. It can therefore travel along rays of light, *i. e.*, along paths in the ether through which rays of light are moving.

There is a well-known experiment in hypnotism, in which the patient, placed in a state of semi- or complete unconsciousness, has his brain called into a more or less active condition by the suggestions of the hypnotizer, which might seem to somewhat favor the hypothesis of cerebral radiation.

It might be interesting, in view of the above suggestions, to see whether a hypnotizer, placed in such a position as regards the hypnotized that flashes of light falling on his eyes shall afterwards fall on the eyes of the patient, to observe whether or not acts of suggestion are more readily perceived by the brain of the hypnotized along such rays of light than without the aid of such rays.

If the preceding speculations be regarded as wild, and that this is true I have already granted, what may not be said as to the following?

If thought radiations partake of the nature of ether-waves, then there should presumably exist in the thought radiations or waves, phenomena corresponding to the various phenomena of thermal, luminous, electric, or magnetic radiation; even the phenomena of reflection, refraction, and possibly even of dispersion of such waves, would appear to be a possibility. In this connection, it is of interest to imagine the analysis or separation of a complex wave of thought into its component or elementary waves, corresponding to the separation of a beam of light, by means of a prism.

In this connection, there would be a new significance in the phrases, "radiant with thought," or, "to concentrate one's thoughts on a subject."

If thought radiations or waves partake of the nature of light, then it would seem among the remote possibilities of science—to obtain, say by means of a lens—a photographic impression of such thought-waves on a suitably sensitized plate, somewhat after the manner of the ordinary photographic picture. Such a thought-record, suitably employed, might be able to awaken at any subsequent time in the brain of a person submitting himself to its influences, thoughts identical to those recorded.

Of course, I am aware of the improbability of such a record being obtained in the near future, and of the exceeding difficulties that would seem to stand in the way of ever obtaining it.

Until we know something more definite concerning the nature of these assumed cerebral vibrations and of their lengths, we must necessarily be seriously handicapped as how to best permanently fix them on a suitable record-surface, and how afterwards to cause such record-surface to interpret its peculiarities to the brain. I merely throw it out as a possibility of what science may have in store for those who come after us. I would suggest, in this connection, that 100 years ago it would probably have been regarded as quite impossible that the telephone or the phonograph could have been produced.

Such a thought-record, however, if obtained would not be an image of the thought itself, or of the particular groupings of the particles, whose to-and-fro movements attend or produce thought, any more than the tracings of the phonograph record form an image of the spoken words. They would merely represent the to-and-fro motions of the ether set in motion by the thought or cerebrations.

An eye looking at such an image would not be influenced thereby. If, however, ether waves similar to those recorded could be reproduced by causing light to pass through such photographic images of the to-and-fro motions of thought-waves, such waves might be caused to influence the brain and thereby awaken thoughts similar or identical to those recorded.

I have often amused myself with picturing a possible thought-recording machine, whereby the thoughts of an active brain might be recorded continuously and permanently on a moving sensitized film, the exposed surface of which was placed at the focus of a large lens placed in front of any one engaged in intense thought.

If, like the cylinder or plate of a phonograph or gramophone, such a record were afterward rotated at the same speed as that at which it received its impressions, under circumstances in which light passing through it is moulded

into waves similar to those recorded on it, such waves when caused to act on a receptive brain, should, it would certainly seem, excite therein thoughts identical to those recorded as its record-surface.

Of course, it is needless for me to say that such a machine has never been actually constructed and is still as unsubstantial as are the speculations which I have offered you. Indeed, the probabilities against its being produced are so great that I have hesitated even to mention it.

Some experiments might be tried in a similar manner in thought transference, by holding large lenses in front of the eyes of a hypnotizer at such a distance as to converge the assumed cerebral radiations on the eyes of the hypnotized. These experiments might be tried either along with light, or independent of it.

I know that many points of the hypothesis which I have suggested are quite improbable, and that I may and probably will be misunderstood by some as putting forward facts rather than a bare hypothesis.

Probably one of the most serious objections to the hypothesis is to be found in the fact that the phenomena of telepathy and thought transference are not of more frequent occurrence. This I must frankly acknowledge to be a most serious objection. I would suggest, however, that the comparative infrequency of the phenomena may possibly be explained by the presence in the human body of a shield which protects the brain or the nerve centres from the effects of cerebral radiations. It is not impossible the sheathes of the nerves act as screens to prevent the reception by the brain of these thought radiations.

Prof. Tyndall, in his work on sound, alludes to the well-known fact that when sympathetic vibrations are being excited by a sounding tuning-fork in any body near it, that there is a greater rapidity of expenditure of energy of the fork's motion than when it was not exciting such waves. The analogue of this phenomena exists, perhaps, in the case of the assumed thought transference. Mental energy is presumably expended at a greater rate when it is exciting thought-waves in this manner, than when such are not being excited.

There has often been experienced by me as a teacher a feeling of great exhaustion in taking charge of or watching a room in which a number of bright students were undergoing an examination. It is possible that the cause of this exhaustion is the rapid dissipation of energy by the cerebral radiations being absorbed by the receptive brains of the examinees. I am informed by certain physicians, that a feeling of great exhaustion is experienced by them in the treatment of some cases.

If there be any truth in the hypothesis I have briefly outlined, there should be what I would term a kind of vital radiation going on and passing outwards from the body of a healthy person, which may not improbably excite by sympathetic vibrations in the bodies of weaker persons around them, vibrations of a normal or more healthy type than those present in the sick person.

If this be true, the old belief of the efficacy of the laying on of hands, or of magnetic healing, may find some foundation, in fact, apart from what is most probably the general explanation of such causes, viz., hysteria.

I have thrown out the above hypothesis of cerebral radiations with considerable doubt and hesitation as a suggestion only to those working in the field of telepathy or thought transference, in the hope that I may thereby call the attention of such investigators to some phenomena in this very obscure field of research.

DYNAMO AND MOTOR CALCULATION.

By C. H. Bedell.

[*Read at the stated meeting of the Electrical Section, April 5, 1892.*]

In the calculation of the different parts of a dynamo or motor, the work is of course divided into the calculation of the armature, and that of the field; but as the capacity and smooth operation depend principally upon the construction of the armature, it should be worked out first. This work is best divided into two parts; and since the dynamo is

primarily a generator of E. M. F., the first consists of the calculation of those parts which affect the generation of the E. M. F., and the second in proportioning the parts that they will stand the currents which may be allowed to flow.

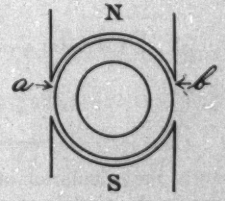
The part of the work which I wish now to consider, is that of the generation of the E. M. F.

For this, one must know to what extent the proposed field will saturate the armature core, since the E. M. F. is generated by the wires of the armature cutting the lines of force which the field causes to pass through the armature core.

One definition of a unit of E. M. F., is that E. M. F. generated by a conductor cutting one line of force once a second. Broadly the E. M. F. generated = lines of force cut × number of times they are cut per second. The E. M. F. is consequently proportional to the number of lines of force cut, and also the rate at which they are cut.

The rate at which the lines of force are cut is easily obtained, for the total number of conductors on the surface of the armature T, multiplied by the revolutions per second R, gives the number of conductors which cut the lines of force in a second, or the rate per second.

The number of lines of force cut is obtained by multiplying the number of square inches of iron in the cross-section of the armature core C, by the number of lines of force which is known will produce the desired degree of saturation L. Knowing the rate of cutting, and the number of lines of force, we have then the E. M. F. (in absolute units)



$$= T \times R \times C \times L,$$

or

$$\frac{E.\,M.\,F.}{10^8} = \frac{T \times R \times C \times L}{10^8} = \text{volts.}$$

This equation has only one factor about which there can be any uncertainty, which is the factor L; but as a very slight acquaintance with the form of dynamo to be constructed, or a careful calculation of the magnet circuit, will

give the possible degree of saturation, there can be said to be very little uncertainty even in this factor.

The most satisfactory degree of saturation of the armature core, is with 90,000 to 100,000 lines of force per square inch of iron in the cross-section of the armature core, which can be obtained with the usual percentage of watts used in the field.

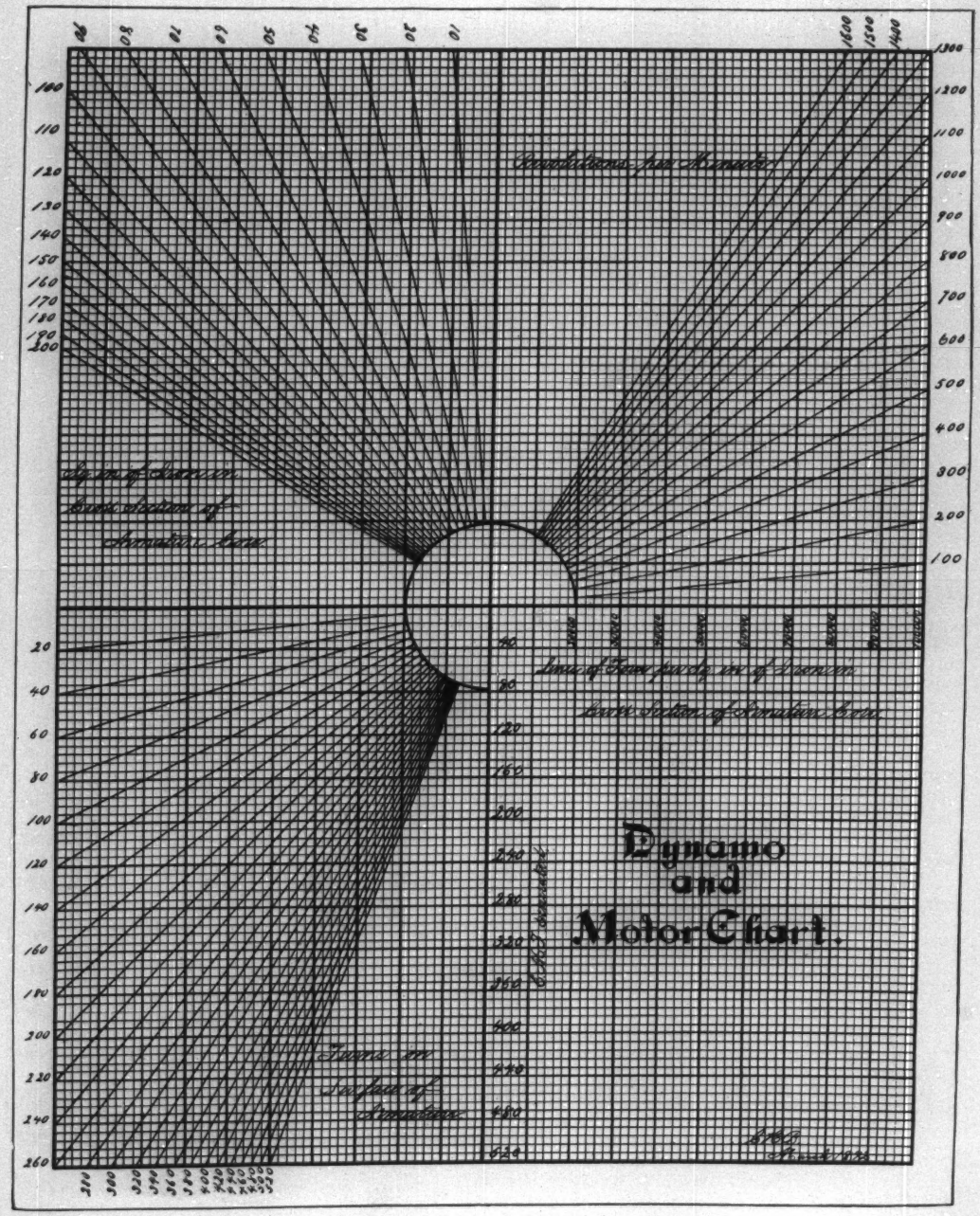
The annexed chart will greatly facilitate this calculation. It is of the same general plan as Mr. Carl Hering's wiring charts published in his *Wiring Computer*, and is used in the same manner. The interpolations for values between the diagonal lines are different in this chart, as the readings in the upper left-hand field should be along a horizontal line, and those in the upper right-hand, and in the lower left-hand field, should be along vertical lines.

It will be noticed that although the chart covers all the usual sizes of generators, yet calculations can be made with it far beyond its limits, as the different factors are so related to each other that where one is changed another can be changed porportionately, except in the case of lines of force per square inch. In the case of lines of force per square inch, values cannot be obtained higher than 100,000 lines per square inch with economy, on account of the iron being saturated at about that point.

If higher values of E. M. F. are desired than those given, the figures in the scale of E. M. F. can be doubled, provided any one of the others, except the lines of force per square inch, is doubled also.

Or if very low values of E. M. F. are desired, the scale of E. M. F. can be divided by any factor, provided any one of the other scales be divided by the same factor.

As an illustration of the use of the chart, let us suppose we have a dynamo having 200 times on the surface of the armature sixty square inches of iron in the cross-section of the armature core, and we desire to know at what speed it will be necessary to run the armature to generate 200 volts. Starting at the 200 point in the column marked "E. M. F. generated," follow the line to the left until it intersects the line representing 200 turns; then follow the


Dynamo
and
Motor Chart.

vertical line from that point until it intersects the line representing sixty square inches cross-section; then follow the line to the right until it intersects the line representing the probable degree of saturation, which in this case we will say is 100,000 lines of force per square inch. The speed line which also crosses at this point is the speed required, and is exactly 1,000 revolutions per minute. If only 90,000 lines of force per square inch could be obtained, the speed required would then be a little over 1,100 revolutions per minute. It will be noticed that the form of the armature, amount of active wire, or volts per foot of active wire, do not enter into the calculation. In this method the number of lines of force which pass from any one pole into the armature core and the rate which the wires cut these lines of force form the basis of calculation.

The maximum $P_1 D_1$ is between two points on the armature wire which just include all the lines of force which pass through the armature, to or from any one pole, as at *a* and *b* in the figure, if we are working with the lines which pass from the north pole.

As far as the E. M. F. generated between *a* and *b* is concerned, it makes no difference in a ring armature what becomes of the lines of force after they pass those points, or what the other wires on the surface of the armature are doing. In a two-pole field the other portion of the armature wire, passing under the south pole, cuts the same lines of force, and consequently the same number, and since the rate of cutting them is the same, the E. M. F. generated is exactly the same as that generated under the north pole. But as these two E. M. F.'s are in opposite directions no current flows around the armature, although the points of greatest $P_1 D_1$ are joined together by the parts of the armature wire not under the poles.

Since what becomes of the lines of force after passing the points *a* and *b* of a ring armature, or what the armature wires not between *a* and *b* are doing, makes no difference to the E. M. F. generated between *a* and *b*, the lines of force may be divided so as to pass from the armature into different poles, and the armature wires not between *a* and *b*

may pass under any odd number of poles, and may generate under those poles different E. M. F.'s from those under the pole first considered. It is usual, however, to so build the different portions of a multipolar field, that the E. M. F. generated under the poles is the same in amount, in order that all the terminals of the same potential may be joined together, thus connecting the different portions of the armature in parallel.

The methods of calculation given above, either by formula or chart, deal with the generation of the E. M. F. under one pole only, and consequently can be used for any direct current dynamo having a ring armature, whether for bipolar or multipolar fields.

In the case of drum armatures the conditions are a little different, as the return portion of a wire under the north pole passes under the south pole and generates an E. M. F. which is added to that generated under the north pole, increasing the E. M. F. between *a* and *b*. But the adjoining wire does not give its E. M. F. to *a* and *b*, but to corresponding points adjacent to the south pole. Consequently, it may be considered that the one wire offsets the other, and the same formula and the chart hold good for drum armatures also.

In cases of multipolar machines having the E. M. F.'s generated under like poles in series, the E. M. F., either of formula or chart, should be increased in proportion to the number of such poles.

The square inch of iron in the cross-section mentioned above has reference to the iron in the cross-section through which the lines of force pass from any one pole.

The E. M. F. generated may be that of a dynamo, or that of a motor in the form of counter E. M. F. In each case allowance should be made for the loss in voltage due to the resistance of the armature, and also to whatever loss of E. M. F. there may be due to the lead of the brushes.

BOOK NOTICES.

Woodbridge School Essays. No. I. Theoretical Astronomy. Dynamics of the Sun. By J. Woodbridge Davis. New York: D. Van Nostrand Company.

This work is apparently intended to bring before the scientific world an hypothesis by which the explanation of a number of cosmical phenomena is attempted that have heretofore defied rational explanation.

The author begins with an analytical examination of the dynamic relation existing between the atmosphere and the nucleus of an imaginary orb, the atmosphere consisting of the vapors of the fluids and solids composing the nucleus. The laws governing the evaporation or condensation or both in the several strata of the atmosphere, as dependent on the conditions of heat, are carefully evolved and analytically presented.

Upon applying the results of this analysis to the sun, the author concludes that there is evaporation but no condensation on the sun, the vapors formed possessing such a tension that the velocity attained by adiabatic expansion is sufficient to hurl the molecules into space beyond the reach of solar attraction. In order to account for the heat required, it is assumed that at the exalted temperature prevailing on the sun the so-called chemical elements are dissociated into a lower grade of elements capable of reuniting as the temperature on the surface of the nucleus is lowered to the limit of dissociation.

This outflying solar atmosphere, in reflecting the solar light, is assumed to account for the corona and the zodiacal light. Then it is shown that this current, in sweeping past the planets, dividing, as a stream of water would on encountering an immersed sphere, not only carries away portions of the planetary atmospheres ultimately denuding those orbs of the last trace of their gaseous envelopes, as shown by the moon, but, being charged with positive electricity, resulting from the process of elementary combination, this current is supposed to account for many magnetic and electric phenomena observed on our globe. And finally, by describing comets as being surrounded by atmospheres of enormous dimensions, of which a portion is swept into space, the phenomenon of cometary tails is explained.

This work, abounding with assertions of a purely hypothetical character, fails to carry conviction to the reader. Indeed, he feels that, while this theory appears to throw light on some phenomena, it precludes the explanation heretofore given to others. The theory of Laplace is reversed; progressive dispersion of the mass of the sun is put in place of progressing concentration. The student is led to ask himself why the forces, inherent in the sun, tending to disperse this mass, will not act more rapidly, since we are wont to see such phenomena take the form of sudden explosions, as exemplified by allowing the superheated water of a steam boiler to escape from its confinement. The author here avails himself of the hypothesis of the composite nature of the so-called elements and their dissociation at high temper-

ature. No satisfactory explanation is given why the equatorial streams of the solar atmosphere should predominate to such a degree as would be necessary to account for the convergent form of the zodiacal light. Then it would be more consistent with modern notions to assume that the outlying atmosphere, on encountering a planet, would be intercepted and arrested rather than deflected and thrown aside, such deflection being always a result of decreased pressure due to reaction, and the pressure of the outlying atmosphere being almost infinitesimal, it is difficult to imagine a cause for deflection. One would therefore expect an increase of the atmospheres of secondary orbs rather than a diminution. The theory of magnetic and electric phenomena appears strained in many respects. It is by no means clear why the particles projected into space should be charged with electricity. And if such were the case, the mass of the sun must have long since been overcharged with negative, and that of the earth with positive electricity, and the admission at the end of the respective chapter that "according to the theory, the sun is becoming negatively charged, and the planets positively charged with electricity," makes an impression as if some one would admit that a drop of water may occasionally come down the Falls of Niagara. In support of the assertion that the nuclei of comets are surrounded by immense atmospheres, the records of observations are quoted according to which stars seen through the cometic vapors showed a sensible increase of brilliancy, while according to our knowledge of optics, stars seen through a refracting sphere should have shown a diminished brilliancy, except if the observer had been within the focal distance of this cosmic lens.

The analysis of the dynamics of atmospheres surrounding celestial orbs, notwithstanding the difficulties which such an abstruse subject necessarily presents, is well conceived and carefully carried out, but the theory of the outflying atmosphere of the sun is so radically at variance with modern conceptions and appears to be so replete with inconsistencies that it is not likely to find a permanent place in theoretical astronomy. H. B.

The Elements of Physical Geography, for the use of schools, academies and colleges. By Edwin J. Houston, A.M., Prof. of Physical Geography and Natural Philosophy in the Central High School of Philadelphia, etc. (Revised edition.) Philadelphia: Published by Eldredge & Bro., No. 17 North Seventh Street. 1891.

The unqualified success of the original edition of this admirable work, as evidenced by its extensive adoption throughout the country as a text-book in the schools, has amply justified the warm praise bestowed upon it in the *Journal* by the present reviewer on its first appearance. The present edition is a revision of the original, which, the author explains, has been made necessary by the progress of science, which has required the abandonment of certain theoretical views and the modification of others, by reason of the expansion of our knowledge.

We are pleased to notice that the author has wisely held fast to the same general style of treatment, and to the same order of sequence of topics followed in the original impression of the work. While a careful reading of

the present edition and an inspection of the illustrations reveal the hand of the judicious reviser in many places, the book retains its identity, and in its present form, we doubt not, will prove more acceptable than ever to the fraternity of teachers. W. H. W.

Brick for Street Pavements. An account of tests made of bricks and paving blocks, with a brief discussion of street pavements and the method of constructing them. By M. D. Burke, C.E. Cincinnati: Robert Clarke & Co. 1892. 8vo. Paper. Price, 50 cents.

The pamphlet above-named contains the record of what appears to be a very thorough series of tests made by the author upon fifteen samples representing as many varieties of bricks and blocks manufactured for street paving purposes. Each sample was from a different establishment, and the whole collection, the author believes, fairly represents the paving brick of the day, as manufactured in various parts of the United States.

The examination made embraced a chemical analysis, tests of water absorption, specific gravity, transverse and crushing strength, and resistance to abrasion and impact. Details of the entire work, the history of the samples, the mode of preparing them for test, the data of the tests themselves and the results arrived at, are presented in the text and in tabular form for better review and comparison.

The pamphlet contains besides this (which constitutes of course its chief value), some useful considerations from the engineer's standpoint, on the general subject of street paving, municipal methods, etc. W. H. W.

The Transition Curve Field-book. Containing full directions for adjusting and locating a curve nearly identical with the cubic parabola in transition between any circular railroad curve and tangent. By Conway R. Howard, C.E. New York: John Wiley & Sons. 109 pp. Bound in morocco, with flap. Price, $1.50.

This work is issued in convenient pocket book form, for the service of engineers engaged in the location of lines of railway. With the aid of the general table which the author gives, the engineer is enabled readily to adjust the transition curve, so as to connect with any circular curve. The application of the method is fully illustrated by rules and examples. The utility of the book is enhanced by the introduction of tables of radii, sines, tangents, versed sines and external sextants. W.

Notes and Examples in Mechanics, with an appendix on the graphical statics of mechanism. By Irving P. Church, C.E., Associate Professor of Civil Engineering, Cornell University. New York: J. Wiley & Sons. 146 pp., 138 illustrations and six plates. Price, $2.

The "notes and examples," which Prof. Church presents in this volume, are designed especially for the use of advanced students of mechanics. They are intended to illustrate the application of first principles in mechanics of solids. An appendix treats of the "Graphical Statics of Mechanism." The author's experience as a teacher has well qualified him for undertaking the difficult task of presenting his subject clearly, and in his selection of problems he has been very judicious. W.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, May 18, 1892.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 18, 1892

JOS. M. WILSON, President, in the chair.

Present, 132 members and twenty-two visitors.

Additions to membership since last report, nine.

Mr. W. S. Collins, of New York, read a paper descriptive of the system of using petroleum for fuel purposes, as practised by the Aërated Fuel Company, of Springfield, Mass., illustrating with the aid of lantern slides, the mechanical features of the same. The system consists substantially in the employment of compressed air as the vehicle for conveying the oil to the point of combustion, and spraying it into the furnace. This method permits of the location of the oil reservoir *below* the level of the furnaces, thus obviating the danger of flooding the latter with oil in the event of accident by leakage or break-down. (Mr. Collins' paper has been referred for publication).

Mr. C. J. Hexamer presented a paper giving his views of the proper method of constructing buildings designed to be used as theatres, and on the provisions necessary to be made in the interior arrangement and fitting up of such buildings in order to insure adequate protection of human life and property against destruction by fire. In connection with Mr. Hexamer's paper, Mr. Nelson, of New York, exhibited a number of specimens of various textile fabrics and wood that had been subjected to treatment by the Martin fire-proofing process. The experiments which were made in demonstration of the resistance of these specimens to the spread of fire, when brought in contact with, or held for some time directly in the flame of, a gas jet or Bunsen burner were highly successful.

The subject elicited a general discussion. (Mr. Hexamer's paper was referred for publication.)

The Secretary presented, on behalf of Mr. Elwood Ivins, a handsomely framed set of specimens of metal tubes of steel, brass, copper and aluminum, among which were a number that were of extremely small diameter, and in lengths of thirty or more feet. These tubes are seamless, without solder or weld, and are made by a process devised by Mr. Ivins.

Mr. W. N. Jennings exhibited and described a number of remarkable lightning photographs lately made by himself. In order to permit of the more satisfactory and accurate study of the lightning image, Mr. Jennings explained that he had used for these pictures the stereoscopic camera. A number of prints of such pictures mounted in a hand stereoscope were passed about for inspection. Mr. Jennings remarked that so far as he was aware he was the first to employ the stereoscope in this work, and that he was pleased to be able to give the members of the Institute the opportunity of inspecting the first pictures of the kind ever made.

Adjourned.

WM. H. WAHL, *Secretary.*